THE

POPULAR SCIENCE MONTHLY.

APRIL, 1876.

ON THE BORDER TERRITORY BETWEEN THE ANIMAL AND THE VEGETABLE KINGDOMS.

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IN the whole history of science there is nothing more remarkable than the rapidity of the growth of biological knowledge within the last half century, and the extent of the modification which has thereby been effected in some of the fundamental conceptions of the naturalist.

In the second edition of the "Règne Animal," published in 1828, Cuvier devotes a special section to the "Division of Organized Beings into Animals and Vegetables," in which the question is treated with that comprehensiveness of knowledge and clear critical judgment which characterize his writings, and justify us in regarding them as representative expressions of the most extensive, if not the profoundest, knowledge of his time. He tells us that living beings have been subdivided from the earliest time into *animated beings*, which possess sense and motion, and *inanimated beings*, which are devoid of these functions, and simply vegetate.

Although the roots of plants direct themselves toward moisture, and their leaves toward air and light; although the parts of some plants exhibit oscillating movements without any perceptible cause, and the leaves of others retract when touched, yet none of these movements justify the ascription to plants of perception or of will.

From the mobility of animals, Cuvier, with his characteristic partiality for teleological reasoning, deduces the necessity of the existence in them of an alimentary cavity or reservoir of food, whence their nutrition may be drawn by the vessels, which are a sort of internal roots; and in the presence of this alimentary cavity he naturally sees the primary and the most important distinction between animals and plants.

Following out his teleological argument, Cuvier remarks that the organization of this cavity and its appurtenances must needs vary according to the nature of the aliment, and the operations which it has to undergo, before it can be converted into substances fitted for absorption; while the atmosphere and the earth supply plants with juices ready prepared, and which can be absorbed immediately.

As the animal body required to be independent of heat and of the atmosphere, there were no means by which the motion of its fluids could be produced by internal causes. Hence arose the second great distinctive character of animals, or the circulatory system, which is less important than the digestive, since it was unnecessary, and therefore is absent, in the more simple animals.

Animals further needed muscles for locomotion and nerves for sensibility. Hence, says Cuvier, it was necessary that the chemical composition of the animal body should be more complicated than that of the plant; and it is so, inasmuch as an additional substance, nitrogen, enters into it as an essential element, while in plants nitrogen is only accidentally joined with the three other fundamental constituents of organic beings—carbon, hydrogen, and oxygen. Indeed, he afterward affirms that nitrogen is peculiar to animals; and herein he places the third distinction between the animal and the plant.

The soil and the atmosphere supply plants with water, composed of hydrogen and oxygen; air, consisting of nitrogen and oxygen; and carbonic acid, containing carbon and oxygen. They retain the hydrogen and the carbon, exhale the superfluous oxygen, and absorb little or no nitrogen. The essential character of vegetable life is the exhalation of oxygen, which is effected through the agency of light.

Animals, on the contrary, derive their nourishment either directly or indirectly from plants. They get rid of the superfluous hydrogen and carbon, and accumulate nitrogen.

The relations of plants and animals to the atmosphere are therefore inverse. The plant withdraws water and carbonic acid from the atmosphere, the animal contributes both to it. Respiration—that is, the absorption of oxygen, and the exhalation of carbonic acid—is the specially animal function of animals, and constitutes their fourth distinctive character.

Thus wrote Cuvier in 1828. But, in the fourth and fifth decades of this century, the greatest and most rapid revolution which biological science has ever undergone was effected by the application of the modern microscope to the investigation of organic structure; by the introduction of exact and easily manageable methods of conducting the chemical analysis of organic compounds; and, finally, by the employment of instruments of precision for the measurement of the physical forces which are at work in the living economy.

That the semi-fluid contents (which we now term protoplasm) of the cells of certain plants, such as the *Charœ*, are in constant and

regular motion, was made out by Bonaventura Corti a century ago; but the fact, important as it was, fell into oblivion, and had to be rediscovered by Treviranus in 1807. Robert Brown noted the most complex motions of the protoplasm in the cells of *Tradescantia* in 1831; and now such movements of the living substance of plants are well known to be some of the most widely-prevalent phenomena of vegetable life.

Agardh, and other of the botanists of Cuvier's generation, who occupied themselves with the lower plants, had observed that, under particular circumstances, the contents of the cells of certain water-weeds were set free and moved about with considerable velocity, and with all the appearances of spontaneity, as locomotive bodies, which, from their similarity to animals of simple organization, were called "zoöspores."

Even as late at 1845, however, a botanist of Schleiden's eminence deals very skeptically with these statements; and his skepticism was the more justified since Ehrenberg, in his elaborate and comprehensive work on the *Infusoria*, had declared the greater number of what are now recognized as locomotive plants to be animals.

At the present day, innumerable plants and free plant-cells are known to pass the whole or part of their lives in an actively locomotive condition, in no wise distinguishable from that of one of the simpler animals; and, while in this condition, their movements are, to all appearance, as spontaneous—as much the product of volition—as those of such animals.

Hence the teleological argument for Cuvier's first diagnostic character—the presence in animals of an alimentary cavity, or internal pocket, in which they can carry about their nutriment, has broken down—so far, at least, as his mode of stating it goes. And, with the advance of microscopic anatomy, the universality of the fact itself among animals has ceased to be predicable. Many animals of even complex structure, which live parasitically within others, are wholly devoid of an alimentary cavity. Their food is provided for them, not only ready cooked, but ready digested, and the alimentary canal, become superfluous, has disappeared. Again, the males of most rotifers have no digestive apparatus; as a German naturalist has remarked, they devote themselves entirely to the "Minnedienst," and are to be reckoned among the few realizations of the Byronic ideal of a lover. Finally, amid the lowest forms of animal life, the speck of gelatinous protoplasm, which constitutes the whole body, has no permanent digestive cavity or mouth, but takes in its food anywhere; and digests, so to speak, all over its body.

But, although Cuvier's leading diagnosis of the animal from the plant will not stand a strict test, it remains one of the most constant of the distinctive characters of animals. And, if we substitute for the possession of an alimentary cavity the power of taking solid nutri-

ment into the body and there digesting it, the definition so changed will cover all animals, except certain parasites, and the few and exceptional cases of non-parasitic animals which do not feed at all. On the other hand, the definition thus amended will exclude all ordinary vegetable organisms.

Cuvier himself practically gives up his second distinctive mark when he admits that it is wanting in the simpler animals.

The third distinction is based on a completely erroneous conception of the chemical differences and resemblances between the constituents of animal and vegetable organisms, for which Cuvier is not responsible, as it was current among contemporary chemists.

It is now established that nitrogen is as essential a constituent of vegetable as of animal living matter; and that the latter is, chemically speaking, just as complicated as the former. Starchy substances, cellulose and sugar, once supposed to be exclusively confined to plants, are now known to be regular and normal products of animals. Amylaceous and saccharine substances are largely manufactured, even by the highest animals; cellulose is widespread as a constituent of the skeletons of the lower animals; and it is probable that amyloid substances are universally present in the animal organism, though not in the precise form of starch.

Moreover, although it remains true that there is an inverse relation between the green plant in sunshine and the animal, in so far as, under these circumstances, the green plant decomposes carbonic acid, and exhales oxygen, while the animal absorbs oxygen and exhales carbonic acid; yet the exact investigations of the modern chemical investigator of the physiological processes of plants have clearly demonstrated the fallacy of attempting to draw any general distinction between animal and vegetable on this ground. In fact, the difference vanishes with the sunshine, even in the case of the green plant; which, in the dark, absorbs oxygen and gives out carbonic acid like any animal. While those plants, such as the fungi, which contain no chlorophyl and are not green, are always, so far as respiration is concerned, in the exact position of animals. They absorb oxygen and give out carbonic acid.

Thus, by the progress of knowledge, Cuvier's fourth distinction between the animal and the plant has been as completely invalidated as the third and second; and even the first can be retained only in a modified form and subject to exceptions.

But has the advance of biology simply tended to break down old distinctions, without establishing new ones?

With a qualification, to be considered presently, the answer to this question is undoubtedly in the affirmative. The famous researches of Schwann and Schleiden, in 1837 and the following years, founded the modern science of histology, or that branch of anatomy which deals with the ultimate visible structure of organisms, as revealed by the

microscope; and, from that day to this, the rapid improvement of methods of investigation and the energy of a host of accurate observers have given greater and greater breadth and firmness to Schwann's great generalization, that a fundamental unity of structure obtains in animals and plants; and that, however diverse may be the fabrics, or *tissues*, of which their bodies are composed, all these varied structures result from the metamorphoses of morphological units (termed *cells*, in a more general sense than, that in which the word "cells" was at first employed), which are not only similar in animals and in plants respectively, but present a close fundamental resemblance when those of animals and those of plants are compared together.

The contractility which is the fundamental condition of locomotion has not only been discovered to exist far more widely among plants than was formerly imagined, but, in plants, the act of contraction has been found to be accompanied, as Dr. Burdon Sanderson's interesting investigations have shown, by a disturbance of the electrical state of the contractile substance comparable to that which was found by Du Bois-Reymond to be a concomitant of the activity of ordinary muscle in animals.

Again, I know of no tests by which the reaction of the leaves of the sundew and of other plants to stimuli, so fully and carefully studied by Mr. Darwin, can be distinguished from those acts of contraction following upon stimuli, which are called "reflex" in animals.

On each lobe of the bilobed leaf of Venus's fly-trap (*Dionœa muscipula*) are three delicate filaments which stand out at right angles from the surface of the leaf. Touch one of them with the end of a fine human hair, and the lobes of the leaf instantly close together[1] in virtue of an act of contraction of part of their substance, just as the body of a snail contracts into its shell when one of its "horns" is irritated.

The reflex action of the snail is the result of the presence of a nervous system in that animal. A molecular change takes place in the nerve of the tentacle, is propagated to the muscles by which the body is retracted, and, causing them to contract, the act of retraction is brought about. Of course the similarity of the acts does not necessarily involve the conclusion that the mechanism by which they are effected is the same; but it suggests a suspicion of their identity which needs careful testing.

The results of recent inquiries into the structure of the nervous system of animals converge toward the conclusion that the nerve-fibres, which we have hitherto regarded as ultimate elements of nervous tissue, are not such, but are simply the visible aggregations of vastly more attenuated filaments, the diameter of which dwindles down to the limits of our present microscopic vision, greatly as these have been extended by modern improvements of the microscope; and

[1] Darwin, "Insectivorous Plants," p. 289.

that a nerve is, in its essence, nothing but a linear tract of specially modified protoplasm between two points of an organism—one of which is able to affect the other by means of the communication so established. Hence it is conceivable that even the simplest living being may possess a nervous system. And the question whether plants are provided with a nervous system or not thus acquires a new aspect, and presents the histologist and physiologist with a problem of extreme difficulty, which must be attacked from a new point of view and by the aid of methods which have yet to be invented.

Thus it must be admitted that plants may be contractile and locomotive; that, while locomotive, their movements may have as much appearance of spontaneity as those of the lowest animals; and that many exhibit actions comparable to those which are brought about by the agency of a nervous system in animals. And it must be allowed to be possible that further research may reveal the existence of something comparable to a nervous system in plants. So that I know not where we can hope to find any absolute distinction between animals and plants, unless we return to their mode of nutrition, and inquire whether certain differences of a more occult character than those imagined to exist by Cuvier, and which certainly hold good for the vast majority of animals and plants, are of universal application.

A bean may be supplied with water in which salts of ammonia and certain other mineral salts are dissolved in due proportion; with atmospheric air containing its ordinary minute dose of carbonic acid; and with nothing else but sunlight and heat. Under these circumstances, unnatural as they are, with proper management, the bean will thrust forth its radicle and its plumule; the former will grow down into roots, the latter grow up into the stem and leaves of a vigorous bean-plant; and this plant will, in due time, flower and produce its crops of beans, just as if it were grown in the garden or in the field.

The weight of the nitrogenous proteine compounds of the oily, starchy, saccharine, and woody substances contained in the full-grown plant and its seeds will be vastly greater than the weight of the same substances contained in the bean from which it sprang. But nothing has been supplied to the bean save water, carbonic acid, ammonia, potash, lime, iron, and the like, in combination with phosphoric, sulphuric, and other acids. Neither proteine, nor fat, nor starch, nor sugar, nor any substance in the slightest degree resembling them, has formed part of the food of the bean. But the weights of the carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, and other elementary bodies contained in the bean-plant, and in the seeds which it produces, are exactly equivalent to the weights of the same elements which have disappeared from the materials supplied to the bean during its growth. Whence it follows that the bean has taken in only the raw materials of its fabric and has manufactured them into bean-stuffs.

The bean has been able to perform this great chemical feat by the help of its green coloring matter, or chlorophyl, which, under the influence of sunlight, has the marvelous power of decomposing carbonic acid, setting free the oxygen, and laying hold of the carbon which it contains. In fact, the bean obtains two of the absolutely indispensable elements of its substance from two distinct sources; the watery solution, in which its roots are plunged, contains nitrogen but no carbon; the air, to which the leaves are exposed, contains carbon, but its nitrogen is in the state of a free gas, in which condition the bean can make no use of it;[1] and the chlorophyl is the apparatus by which the carbon is extracted from the atmospheric carbonic acid—the leaves being the chief laboratories in which this operation is effected.

The great majority of conspicuous plants are, as everybody knows, green; and this arises from the abundance of their chlorophyl. The few which contain no chlorophyl and are colorless are unable to extract the carbon which they require from atmospheric carbonic acid, and lead a parasitic existence upon other plants; but it by no means follows, often as the statement has been repeated, that the manufacturing power of plants depends on their chlorophyl and its interaction with the rays of the sun. On the contrary, it is easily demonstrated, as Pasteur first proved, that the lowest fungi, devoid of chlorophyl, or of any substitute for it, as they are, nevertheless possess the characteristic manufacturing powers of plants in a very high degree. Only it is necessary that they should be supplied with a different kind of raw material; as they cannot extract carbon from carbonic acid, they must be furnished with something else that contains carbon. Tartaric acid is such a substance; and if a single spore of the commonest and most troublesome of moulds—*Penicillium*—be sown in a saucer full of water, in which tartrate of ammonia, with a small percentage of phosphates and sulphates is contained, and kept warm, whether in the dark or exposed to light, it will in a short time give rise to a thick crust of mould, which contains many million times the weight of the original spore in proteine compounds and cellulose. Thus we have a very wide basis of fact for the generalization that plants are essentially characterized by their manufacturing capacity, by their power of working up mere mineral matters into complex organic compounds.

Contrariwise, there is no less wide foundation for the generalization that animals, as Cuvier puts it, depend directly or indirectly upon plants for the materials of their bodies; that is, either they are herbivorous, or they eat other animals which are herbivorous.

But for what constituents of their bodies are animals thus dependent upon plants? Certainly not for their horny matter; nor for

[1] I purposely assume that the air with which the bean is supplied in the case stated contains no ammoniacal salts.

chondrine, the proximate chemical element of cartilage; nor for gelatine, nor for syntonine, the constituent of muscle; nor for their nervous or biliary substances; nor for their amyloid matters, nor, necessarily, for their fats.

It can be experimentally demonstrated that animals can make these for themselves. But that which they cannot make, but must in all known cases obtain directly or indirectly from plants, is the peculiar nitrogenous matter proteine. Thus the plant is the ideal *prolétaire* of the living world, the worker who produces; the animal, the ideal aristocrat, who mostly occupies himself in consuming, after the manner of that noble representative of the line of Zähdarm, whose epitaph is written in "Sartor Resartus."

Here is our last hope of finding a sharp line of demarkation between plants and animals; for, as I have already hinted, there is a border-territory between the two kingdoms, a sort of no-man's land, the inhabitants of which certainly cannot be discriminated and brought to their proper allegiance in any other way.

Some months ago, Prof. Tyndall asked me to examine a drop of infusion of hay, placed under an excellent and powerful microscope, and to tell him what I thought some organisms visible in it were. I looked and observed, in the first place, multitudes of *Bacteria* moving about with their ordinary intermittent spasmodic wriggles. As to the vegetable nature of these there is now no doubt. Not only does the close resemblance of the *Bacteria* to unquestionable plants, such as the *Oscillatoriæ*, and lower forms of *Fungi*, justify this conclusion, but the manufacturing test settles the question at once. It is only needful to add a minute drop of fluid containing *Bacteria*, to water in which tartrate, phosphate, and sulphate of ammonia are dissolved, and, in a very short space of time, the clear fluid becomes milky by reason of their prodigious multiplication, which, of course, implies the manufacture of living Bacterium-stuff out of these merely saline matters.

But other active organisms, very much larger than the *Bacteria*, attaining in fact the comparatively gigantic dimensions of $\frac{1}{1000}$ of an inch or more, incessantly crossed the field of view. Each of these had a body shaped like a pear, the small end being slightly incurved and produced into a long curved filament, or *cilium*, of extreme tenuity. Behind this, from the concave side of the incurvation, proceeded another long cilium, so delicate as to be discernible only by the use of the highest powers and careful management of the light. In the centre of the pear-shaped body a clear round space could occasionally be discerned, but not always; and careful watching showed that this clear vacuity appeared gradually, and then shut up and disappeared suddenly, at regular intervals. Such a structure is of common occurrence among the lowest plants and animals, and is known as a *contractile vacuole.*

The little creature thus described sometimes propelled itself with

great activity, with a curious rolling motion, by the lashing of the front cilium, while the second cilium trailed behind; sometimes it anchored itself by the hinder cilium and was spun round by the working of the other, its motions resembling those of an anchor-buoy in a heavy sea. Sometimes, when two were in full career toward one another, each would appear dexterously to get out of the other's way; sometimes a crowd would assemble and jostle one another, with as much semblance of individual effort as a spectator on the Grands Mulets might observe with a telescope among the specks representing men in the valley of Chamounix.

The spectacle, though always surprising, was not new to me. So my reply to the question put to me was, that these organisms were what biologists call *Monads*, and though they might be animals, it was also possible that they might, like the *Bacteria*, be plants. My friend received my verdict with an expression which showed a sad want of respect for authority. He would as soon believe that a sheep was a plant. Naturally piqued by this want of faith, I have thought a good deal over the matter; and as I still rest in the lame conclusion I originally expressed, and must even now confess that I cannot certainly say whether this creature is an animal or a plant, I think it may be well to state the grounds of my hesitation at length. But, in the first place, in order that I may conveniently distinguish this "monad" from the multitude of other things which go by the same designation, I must give it a name of its own. I think (though, for reasons which need not be stated at present, I am not quite sure) that it is identical with the species *Monas lens*, as defined by the eminent French microscopist Dujardin, though his magnifying power was probably insufficient to enable him to see that it is curiously like a much larger form of monad which he has named *Heteromita*. I shall, therefore, call it not *Monas*, but *Heteromita lens*.

I have been unable to devote to my *Heteromita* the prolonged study needful to work out its whole history, which would involve weeks, or it may be months, of unremitting attention. But I the less regret this circumstance, as some remarkable observations, recently published by Messrs. Dallinger and Drysdale,[1] on certain monads, relate, in part, to a form so similar to my *Heteromita lens*, that the history of the one may be used to illustrate that of the other. These most patient and painstaking observers, who employed the highest attainable powers of the microscope and, relieving one another, kept watch day and night over the same individual monads, have been enabled to trace out the whole history of their *Heteromita;* which they found in infusions of the heads of fishes of the cod tribe.

Of the four monads described and figured by these investigators,

[1] "Researches in the Life-history of a Cercomonad: a Lesson in Biogenesis," and "Further Researches in the Life-history of the Monads," *Monthly Microscopical Journal*, 1873.

one, as I have said, very closely resembles *Heteromita lens* in every particular, except that it has a separately distinguishable central particle or "nucleus," which is not certainly to be made out in *Heteromita lens;* and that nothing is said by Messrs. Dallinger and Drysdale of the existence of a contractile vacuole in this monad, though they describe it in another.

Their *Heteromita*, however, multiplied rapidly by fission. Sometimes a transverse constriction appeared; the hinder half developed a new cilium, and the hinder cilium gradually split from its base to its free end, until it was divided into two; a process which, considering the fact that this fine filament cannot be much more than $\frac{1}{100000}$ of an inch in diameter, is wonderful enough. The constriction of the body extended inward until the two portions were united by a narrow isthmus; finally they separated, and each swam away by itself, a complete *Heteromita*, provided with its two cilia. Sometimes the constriction took a longitudinal direction, with the same ultimate result. In each case the process occupied not more than six or seven minutes. At this rate, a single *Heteromita* would give rise to a thousand like itself in the course of an hour, to about a million in two hours, and to a number greater than the generally-assumed number of human beings now living in the world in three hours; or, if we give each *Heteromita* an hour's enjoyment of individual existence, the same result will be obtained in about a day. The apparent suddenness of the appearance of multitudes of such organisms as these, in any nutritive fluid to which one obtains access, is thus easily explained.

During these processes of multiplication by fission, the *Heteromita* remains active; but sometimes another mode of fission occurs. The body becomes rounded and quiescent, or nearly so, and, while in this resting state, divides into two portions, each of which is rapidly converted into an active *Heteromita*.

A still more remarkable phenomenon is that kind of multiplication which is preceded by the union of two monads, by a process which is termed *conjugation*. Two active *Heteromitæ* become applied to one another, and then slowly and gradually coalesce into one body. The two nuclei run into one; and the mass resulting from the conjugation of the two *Heteromitæ*, thus fused together, has a triangular form. The two pairs of cilia are to be seen, for some time, at two of the angles, which answer to the small ends of the conjoined monads; but they ultimately vanish, and the twin organism, in which all visible traces of organization have disappeared, falls into a state of rest. Sudden wave-like movements of its substance next occur; and, in a short time, the apices of the triangular mass burst, and give exit to a dense yellowish, glairy fluid filled with minute granules. This process, which, it will be observed, involves the actual confluence and mixture of the substance of two distinct organisms, is effected in the space of about two hours.

The authors whom I quote say that they "cannot express" the excessive minuteness of the granules in question, and they estimate their diameter at less than $\frac{1}{200000}$ of an inch. Under the highest powers of the microscope at present applicable, such specks are hardly discernible. Nevertheless, particles of this size are massive when compared to physical molecules; whence there is no reason to doubt that each, small as it is, may have a molecular structure sufficiently complex to give rise to the phenomena of life. And, as a matter of fact, by patient watching of the place at which these infinitesimal living particles were discharged, our observers assured themselves of their growth and development into new monads. These, in about four hours from their being set free, had attained a sixth of the length of the parent, with the characteristic cilia, though at first they were quite motionless; and in four hours more they had attained the dimensions and exhibited all the activity of the adult. These inconceivably minute particles are therefore the germs of the *Heteromita;* and from the dimensions of these germs it is easily shown that the body formed by conjugation may, at a low estimate, have given exit to 30,000 of them; a result of a matrimonial process whereby the contracting parties, without a metaphor, "become one flesh," enough to make a Malthusian despair of the future of the universe.

I am not aware that the investigators from whom I have borrowed this history have endeavored to ascertain whether their monads take solid nutriment or not; so that, though they help us very much to fill up the blanks in the history of my *Heteromita*, their observations throw no light on the problem we are trying to solve—Is it an animal or is it a plant?

Undoubtedly it is possible to bring forward very strong arguments in favor of regarding *Heteromita* as a plant.

For example, there is a fungus, an obscure and almost microscopic mould, termed *Peronospora infestans.* Like many other fungi, the *Peronosporæ* are parasitic upon other plants; and this particular *Peronospora* happens to have attained much notoriety and political importance, in a way not without a parallel in the career of notorious politicians, namely, by reason of the frightful mischief it has done to mankind. For it is this *Fungus* which is the cause of the potato-disease; and, therefore, *Peronospora infestans* (doubtless of exclusively Saxon origin, though not accurately known to be so) brought about the Irish famine. The plants afflicted with the malady are found to be infested by a mould, consisting of fine tubular filaments, termed *hyphæ*, which burrow through the substance of the potato-plant, and appropriate to themselves the substance of their host; while, at the same time, directly or indirectly, they set up chemical changes by which even its woody framework becomes blackened, sodden, and withered.

In structure, however, the *Peronospora* is as much a mould as the

common *Penicillium;* and just as the *Penicillium* multiplies by the breaking up of its hyphæ into separate rounded bodies, the spores, so, in the *Peronospora*, certain of the hyphæ grow out into the air through the interstices of the superficial cells of the potato-plant, and develop spores. Each of these hyphæ usually gives off several branches. The ends of the branches dilate and become closed sacs, which eventually drop off as spores. The spores falling on some part of the same potato-plant, or carried by the wind to another, may at once germinate, throwing out tubular prolongations which become hyphæ, and burrow into the substance of the plant attacked. But, more commonly, the contents of the spore divide into six or eight separate portions. The coat of the spore gives way, and each portion then emerges as an independent organism, which has the shape of a bean, rather narrower at one end than the other, convex on one side, and depressed or concave on the opposite. From the depression, two long and delicate cilia proceed, one shorter than the other, and directed forward. Close to the origin of these cilia, in the substance of the body, is a regularly-pulsating contractile vacuole. The shorter cilium vibrates actively, and effects the locomotion of the organism, while the other trails behind, the whole body rolling on its axis with its pointed end forward.

The eminent botanist, De Bary, who was not thinking of our problem, tells us, in describing the movements of these "zoöspores," that, as they swim about, "foreign bodies are carefully avoided, and the whole movement has a deceptive likeness to the voluntary changes of place which are observed in microscopic animals."

After swarming about in this way in the moisture on the surface of a leaf or stem (which, film though it may be, is an ocean to such a fish) for half an hour, more or less, the movement of the zoöspore becomes slower, and is limited to a slow turning upon its axis, without change of place. It then becomes quite quiet, the cilia disappear, it assumes a spherical form, and surrounds itself with a distinct though delicate membranous coat. A protuberance then grows out from one side of the sphere, and, rapidly increasing in length, assumes the character of a hypha. The latter penetrates into the substance of the potato-plant, either by entering a stomate or by boring through the wall of an epidermic cell, and ramifies, as a mycelium, in the substance of the plant, destroying the tissues with which it comes in contact. As these processes of multiplication take place very rapidly, millions of spores are soon set free from a single infested plant; and from their minuteness they are readily transported by the gentlest breeze. Since, again, the zoöspores set free from each spore, in virtue of their powers of locomotion, swiftly disperse themselves over the surface, it is no wonder that the infection, once started, soon spreads from field to field, and extends its ravages over a whole country.

However, it does not enter into my present plan to treat of the

potato-disease, instructively as its history bears upon that of other epidemics; and I have selected the case of the *Peronospora* simply because it affords an example of an organism, which, in one stage of its existence, is truly a "monad," indistinguishable by any important character from our *Heteromita*, and extraordinarily like it in some respects. And yet this "monad" can be traced, step by step, through the series of metamorphoses which I have described, until it assumes the features of an organism, which is as much a plant as an oak or an elm is.

Moreover, it would be possible to pursue the analogy further. Under certain circumstances, a process of conjugation takes place in the *Peronospora*. Two separate portions of its protoplasm become fused together, surround themselves with a thick coat, and give rise to a sort of vegetable egg called an *oöspore*. After a period of rest, the contents of the oöspore break up into a number of zoöspores like those already described, each of which, after a period of activity, germinates in the ordinary way. This process obviously corresponds with the conjugation and subsequent setting free of germs in the *Heteromita*.

But it may be said that the *Peronospora* is, after all, a questionable sort of plant; that it seems to be wanting in the manufacturing power, selected as the main distinctive character of vegetable life; or, at any rate, that there is no proof that it does not get its proteine matter ready made from the potato-plant.

Let us, therefore, take a case which is not open to these objections.

There are some small plants known to botanists as members of the genus *Coleochæte*, which, without being truly parasitic, grow upon certain water-weeds, as lichens grow upon trees. The little plant has the form of an elegant green star, the branching arms of which are divided into cells. Its greenness is due to its chlorophyl, and it undoubtedly has the manufacturing power in full degree, decomposing carbonic acid and setting free oxygen under the influence of sunlight.

But the protoplasmic contents of some of the cells of which the plant is made up occasionally divide, by a method similar to that which effects the division of the contents of the *Peronospora*-spore; and the severed portions are then set free as active monad-like zoöspores. Each is oval and is provided at one extremity with two long active cilia. Propelled by these, it swims about for a longer or shorter time, but at length comes to a state of rest, and gradually grows into a *Coleochæte*.

Moreover, as in the *Peronospora*, conjugation may take place and result in an oöspore; the contents of which divide and are set free as monadiform germs.

If the whole history of the zoöspores of *Peronospora* and *Coleo-*

chæte were unknown, they would undoubtedly be classed among "monads" with the same right as *Heteromita;* why, then, may not *Heteromita* be a plant, even though the cycle of forms through which it passes shows no terms quite so complex as those which occur in *Peronospora* and *Coleochæte?* And, in fact, there are some green organisms, in every respect characteristically plants, such as *Chlamydomonas*, and the common *Volvox*, or so-called "Globe animalcule," which run through a cycle of forms of just the same simple character as those of *Heteromita.*

The name of *Chlamydomonas* is applied to certain microscopic green bodies, each of which consists of a protoplasmic central substance invested by a structureless sac. The latter contains cellulose, as in ordinary plants; and the chlorophyl which gives the green color enables the *Chlamydomonas* to decompose carbonic acid and fix carbon, as they do. Two long cilia protrude through the cell-wall, and effect the rapid locomotion of this "monad," which, in all respects except its mobility, is characteristically a plant.

Under ordinary circumstances the *Chlamydomonas* multiplies by simple fission, each splitting into two or into four parts, which separate and become independent organisms. Sometimes, however, the *Chlamydomonas* divides into eight parts, each of which is provided with four instead of two cilia. These "zoöspores" conjugate in pairs, and give rise to quiescent bodies, which multiply by division, and eventually pass into the active state.

Thus, so far as outward form and the general character of the cycle of modifications through which the organism passes in the course of its life are concerned, the resemblance between *Chlamydomonas* and *Heteromita* is of the closest description. And on the face of the matter there is no ground for refusing to admit that *Heteromita* may be related to *Chlamydomonas*, as the colorless fungus is to the green alga. *Volvox* may be compared to a hollow sphere, the wall of which is made up of coherent Chlamydomonads; and which progresses with a rotating motion effected by the paddling of the multitudinous pairs of cilia which project from its surface. Each *Volvox*-monad has a contractile vacuole like that of *Heteromita lens;* and, moreover, possesses a red pigment-spot like the simplest form of eye known among animals.

The methods of fissive multiplication and of conjugation observed in the monads of this locomotive globe are essentially similar to those observed in *Chlamydomonas;* and, though a hard battle has been fought over it, *Volvox* is now finally surrendered to the botanists.

Thus there is really no reason why *Heteromita* may not be a plant; and this conclusion would be very satisfactory, if it were not equally easy to show that there is really no reason why it should not be an animal.

For there are numerous organisms presenting the closest resem-

blance to *Heteromita*, and, like it, grouped under the general name of "Monads," which, nevertheless, can be observed to take in solid nutriment, and which therefore have a virtual, if not an actual, mouth and digestive cavity, and thus come under Cuvier's definition of an animal. Numerous forms of such animals have been described by Ehrenberg, Dujardin, H. James Clark, and other writers on the *Infusoria*.

Indeed, in another infusion of hay in which my *Heteromita lens* occurred, there were innumerable infusorial animalcules belonging to the well-known species *Colpoda cucullus*.[1]

Full-sized specimens of this animalcule attain a length of between $\frac{1}{300}$ or $\frac{1}{400}$ of an inch, so that it may have ten times the length and a thousand times the mass of a *Heteromita*. In shape it is not altogether unlike *Heteromita*. The small end, however, is not produced into one long cilium, but the general surface of the body is covered with small, actively-vibrating ciliary organs, which are only longest at the small end. At the point which answers to that from which the two cilia arise in *Heteromita*, there is a conical depression, the mouth; and in young specimens a tapering filament, which reminds one of the posterior cilium of *Heteromita*, projects from this region.

The body consists of a soft granular protoplasmic substance, the middle of which is occupied by a large oval mass called the "nucleus;" while at its hinder end is a "contractile vacuole," conspicuous by its regular rhythmic appearances and disappearances. Obviously, although the *Colpoda* is not a monad, it differs from one only in subordinate details. Moreover, under certain conditions, it becomes quiescent, incloses itself in a delicate case or *cyst*, and then divides into two, four, or more portions, which are eventually set free and swim about as active *Colpodæ*.

But this creature is an unmistakable animal, and full-sized *Colpodæ* may be fed as easily as one feeds chickens. It is only needful to diffuse very finely-ground carmine through the water in which they live, and, in a very short time, the bodies of the *Colpodæ* are stuffed with the deeply-colored granules of the pigment.

And if this were not sufficient evidence of the animality of *Colpoda*, there comes the fact that it is even more similar to another well-known animalcule, *Paramæcium*, than it is to a monad. But *Paramæcium* is so huge a creature compared with those hitherto discussed—it reaches $\frac{1}{120}$ of an inch or more in length—that there is no difficulty in making out its organization in detail; and in proving that it is not only an animal, but that it is an animal which possesses a somewhat complicated organization. For example, the surface-layer of its body is different in structure from the deeper parts. There are two contractile vacuoles, from each of which radiates a system of vessel-like canals; and not only is there a conical depression continu-

[1] Excellently described by Stein, almost all of whose statements I have verified.

ous with a tube, which serve as mouth and gullet, but the food ingested takes a definite course and refuse is rejected from a definite region. Nothing is easier than to feed these animals and to watch the particles of indigo or carmine accumulate at the lower end of the gullet. From this they gradually project, surrounded by a ball of water, which at length passes with a jerk, oddly simulating a gulp, into the pulpy central substance of the body, there to circulate up one side and down the other, until its contents are digested and assimilated. Nevertheless, this complex animal multiplies by division, as the monad does, and, like the monad, undergoes conjugation. It stands in the same relation to *Heteromita* on the animal side, as *Coleochæte* does on the plant side. Start from either, and such an insensible series of gradations leads to the monad that it is impossible to say at any stage of the progress, Here the line between the animal and the plant must be drawn.

There is reason to think that certain organisms which pass through a monad stage of existence, such as the *Myxomycetes*, are, at one time of their lives, dependent upon external sources for their proteine-matter, or are animals, and at another period manufacture it, or are plants. And, seeing that the whole progress of modern investigation is in favor of the doctrine of continuity, it is a fair and probable speculation—though only a speculation—that, as there are some plants which can manufacture proteine out of such apparently intractable mineral matters as carbonic acid, water, nitrate of ammonia, and metallic salts, while others need to be supplied with their carbon and nitrogen in the somewhat less raw form of tartrate of ammonia and allied compounds, so there may be yet others, as is possibly the case with the true parasitic plants, which can only manage to put together materials still better prepared—still more nearly approximated to proteine—until we arrive at such organisms as the *Psorospermiæ* and the *Panhistophyton*, which are as much animal as vegetable in structure, but are animal in their dependence on other organisms for their food.

The singular circumstance observed by Meyer, that the *Torula* of yeast, though an indubitable plant, still flourishes most vigorously when supplied with the complex nitrogenous substance, pepsin; the probability that the *Peronospora* is nourished directly by the protoplasm of the potato-plant; and the wonderful facts which have recently been brought to light respecting insectivorous plants, all favor this view; and tend to the conclusion that the difference between animal and plant is one of degree rather than of kind; and that the problem, whether, in a given case, an organism is an animal or a plant, may be essentially insoluble.—*Macmillan's Magazine.*

AN INTERESTING BIRD.

By J. H. KIDDER, M. D.,
PASSED ASSISTANT SURGEON, UNITED STATES NAVY.

KERGUELEN Island is in latitude 48°–49° south; longitude 70° east from Greenwich. That is to say, it is in the South Indian Ocean, about half-way between the Cape of Good Hope and Australia, but well to the southward of both. It is rather an archipelago than an island, innumerable small peaks being grouped around and in the estuaries of a central mass of volcanic rock, about ninety miles long by fifty wide, and shaped somewhat like a spider, of which its numerous long promontories and peninsulas represent the legs. Being treeless, barren, uninhabited, and uninhabitable, and situated in a region given over to boisterous gales and continual rain or snow, it is a country seldom visited. It was discovered about a hundred years ago, by the unfortunate Lieutenant Kerguelen, of the French marine, and about two years afterward found again by Captain Cook, who gave it the name of Desolation Island. During May, June, and July, 1840, Sir James Clark Ross remained there with the Erebus and Ter-

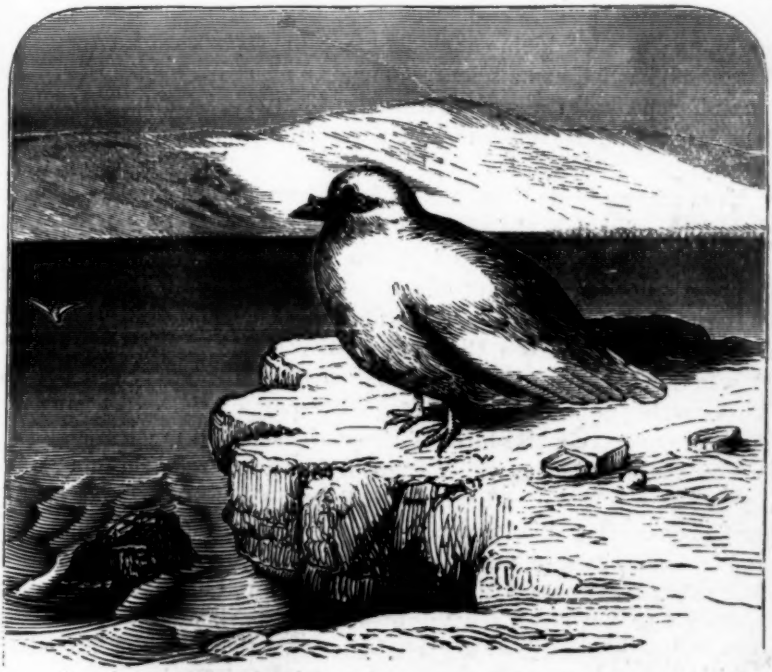


FIG. 1.—THE SHEATH-BILL OF KERGUELEN ISLAND.

ror; and it is to this visit, and to the fact that Dr. Joseph D. Hooker was botanist to the expedition, that we owe our present full knowledge of the botany of the island. Had it not been long noted as a favorite breeding-place for the sea-elephant, and hence resorted to by sealers and whalers, it is doubtful whether any human being, other than the intrepid explorers already alluded to, would have cared to visit so desolate and forbidding a spot, until it came to be fixed upon as a locality whence the transit of Venus could advantageously be observed.

Lying, as this island does, upon the very skirts of the world, far removed from any large body of land, and so placed as to be very unlikely to receive additions to its flora and fauna by the agency of either winds or currents, it was to be expected that its natural history would present very many peculiarities, both of form and of adaptation. Its flora, accordingly, and invertebrate animal life include an unusually large number of genera and species peculiar to the island and its near neighbors; a fact which, considered in connection with its geological characters, has led some scientific men[1] to regard it as one of the few remaining peaks of a great Antarctic Continent, probably (judging from its botanical relations) once continuous with that of South America.

Even among birds there are at least two species not found elsewhere, one of which, the *Chionis minor* of Hartlaub, or White Paddy, sheath-bill, and "sore-eyed pigeon" of sealers and whalers, I propose to give a short account of.

It was first seen by the transit-of-Venus parties and ship's company of the Swatara on the 11th of September, 1874, as that vessel was steaming up Royal Sound toward the spot selected as the observing station of the Kerguelen part of the expedition. It was a very pretty white bird, of about the size and much the appearance of a large pigeon, which came flying over from the shore, and alighted on the keel of a boat that had been secured bottom-up at the stern-davits. It walked up and down the keel of the boat, turning its head from side to side, and examining with great curiosity the crowd of interested spectators gathered on the poop, but showing not the slightest fear. After a few minutes it flew back again, with a note, while flying, not unlike the "chat-chat" of the common blackbird. That afternoon several were caught without difficulty; some were knocked down with stones, and some were actually taken, unhurt, by hand, being approached very gradually, and fed with crumbs until they came within reach.

The nearer examination thus afforded gave us a plump bird, much like a pigeon in size and shape, of pure white, very soft and downy plumage, and with bright black eyes, surrounded by a quite distinct,

[1] *See* "Flora Antarctica," by Dr. J. D. Hooker (London, Reeve Brothers, 1847), vol ii., pp. 210–220, *inter alia*.

pale-pink eyelid (whence the name "sore-eyed pigeon"). The bill was black, conical, and very strong; the nostrils oval, placed at about the centre of the bill, and directed fore-and-aft. Covering just half of the nostril on each side was the curved anterior edge of a saddle-shaped horny sheath (Fig. 2), also black, and bestriding the posterior half of the bill. The pommel of the saddle was canted upward, so as to clear the bill by about three-tenths of an inch; its cantle was lost in the short feathers covering the forehead, and the flaps continued downward on each side, becoming soldered to the upper mandible

FIG. 2.—HEAD OF CHIONIS MINOR.

near its base. On each side they sent up a black fleshy process (caruncle), deeply pitted with holes, which lay in contact with the upper eyelid. And, a fact not before observed, on clipping away the forehead-feathers, this black fleshy mass was found to extend entirely across the forehead, like the upper part of a black-silk domino, the little feathers which hide it during life passing through the holes with which it was everywhere pitted (Fig. 3). The legs were stout, pale flesh-colored, and scaly, with large, pavement-like knobs, but not what ornithologists call "scutellated," excepting over the upper surfaces of the toes. There were four toes, the first or hinder one being of good size for a hind-toe, and elevated above the rest, arising a little to the inner side of the leg. The claws were large, blunt, and black, and on the wrist-joint of each wing was a small black knob, like a spur (flesh-colored in females and young birds), which was afterward found to be supported by a distinct bony process, or exostosis, from the bone of the wing. The tail was very slightly rounded, and composed of twelve feathers—the wing-primaries were ten, and the first three of equal length.

It may be as well to mention here that this species was erected by Dr. Hartlaub in 1841, when he wrote to the *Revue Zoölogique*[1]

[1] *Revue Zoölogique*, 1841, p. 5.

that he had found in the museum at Leyden a new species of chionis, "patrie inconnue." He called it *Chionis minor*, and distinguished it from Forster's *Chionis alba*, described in 1788, as being of smaller size, having a *black* bill and sheath, and a fleshy process of the same color over the eye. He also noted the color of the thickened eyelid and of the legs, and gave measurements of the principal dimensions. In 1842 [1] appeared in the same journal a drawing of the head of the Leyden specimen, also from Dr. Hartlaub.

In 1849 it was figured by G. R. Gray,[2] being classed by him with the *Gallinæ* or fowl order, and associated with two other curious ant-

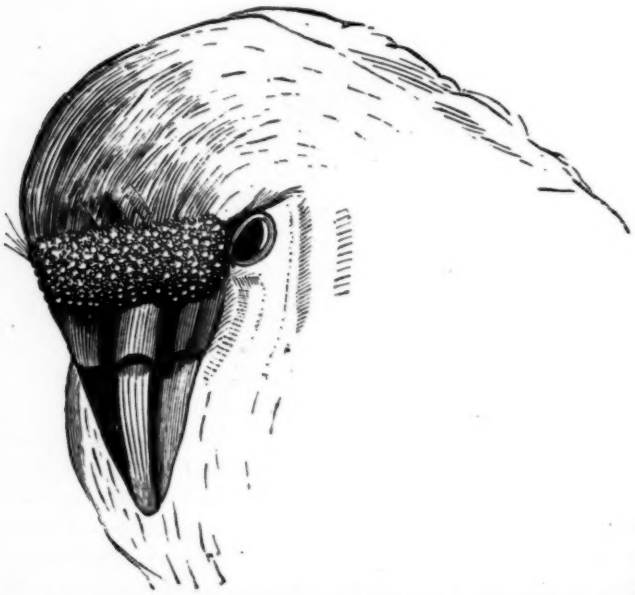


FIG. 3.—BILL OF CHIONIS, WITH FRONTAL FEATHERS CUT AWAY, TO SHOW THE CARUNCLE.

arctic genera, called *Thinocorus* and *Attagis*. It would seem probable that Gray's drawing was made from the Leyden specimen also, since I have been able to find a record of only three other individuals (besides the eleven specimens brought to the National Museum by myself), all of which were sent to the Zoölogical Society. These were: a living specimen sent from Cape Town by Mr. Layard, of which the skin was exhibited to the society by Mr. Sclater, November 28, 1867;[3] and two skins received October 26, 1868,[4] also from Mr. Layard. All three of these specimens came originally from the Crozet Islands, which lie about six hundred miles to the west of Kerguelen, and present substantially the same natural history characteristics.

[1] *Revue Zoölogique*, 1842, pl. 2, Fig. 2.
[2] "Genera of Birds," 1849, p. 522.
[3] "Proceedings of Zoölogical Society," 1867.
[4] Ibid., 1868.

An egg was received by the Zoölogical Society[1] in January, 1871, and described by Mr. Alfred Newton as the first of either species of the genus ever known, overlooking Mr. Layard's description of the egg of *C. minor* published in 1867.[2] Schlegel gives a figure and some description,[3] which I suppose, from the date, to refer also to the Leyden specimen, but have not yet been able to get access to the article.

If there ever were any other specimens, I have not been able to find the record of their receipt; and, whether there be or not, it is very evident that the birds are but little known to science, since the history of the species can be summed up in so few lines.

During a four months' residence on Kerguelen Island I had ample opportunity for observing the habits of the few living things which inhabited it, and none were more interesting in their ways than the chionis. Two or three lived near our huts, frequenting the rocks along the shore between tides. They were particularly plentiful upon a bold promontory called Malloy's Point, where many cormorants nested; and at another place, some two miles away, where the *débris* broken off from lofty, precipitous cliffs had made a sort of "lean-to" of irregular fragments of rocks. Here, likewise, was a nesting-place for cormorants, and also a great rookery of the curious "rock-hoppers," or crested penguins. These two birds were the chosen companions of the chionis, which lived with them on terms of perfect friendship and close association. One day (October 15th), seeing a large number of white specks on the farther side of Malloy's Point, I began to approach them very cautiously, so as to watch their movements at closer quarters. Caution proved, however, to be quite thrown away in that instance, since so great was the curiosity of the birds that they would scarcely get out of my way. When I finally sat down upon a rock and kept perfectly still for a few moments, they crowded around me like a mob of street-boys around an organ-grinder. Others flew up from more distant rocks, apparently called by the short, rattling croaks of those already near, and some came almost within reach of my arm. All seemed perfectly fearless and trustful, and very unlike in this respect to any other birds that I had ever seen. They ran with great swiftness over the rocks, stopping now and then to peck at a common green sea-weed (*ulva*), upon which they seemed to feed, shaking the water from it by a rapid, flirting motion of the bill. In running over the rocks they rather avoided the little pools of water left by the tide, seeming to dislike wetting their feet.

After sufficient time spent in observation, I changed the cartridges in my gun for others loaded with small shot, and moved off, so as to get far enough away to shoot two or three without tearing the skins; not without a good deal of compunction at destroying their friendly

[1] "Proceedings of Zoölogical Society," 1871, p. 57.
[2] Ibid., 1867, p. 458.
[3] Handl. Dierk., pl. 5—De Dierk., Fig., p. 232.

illusions. The interest of all was at once renewed; some started to follow me, making little swift runs and stopping short to look. Even after one had been shot they seemed rather startled than frightened by the noise of the gun. A few flew off for a short distance, but most remained, looking from me to the dead bird with great surprise, so that I was enabled to secure four specimens without moving from where I stood.

On subsequent occasions several specimens were captured alive, by hand, all that was necessary being to remain perfectly still, and feed them with bread-crumbs until they ventured within reach. When brought home, and let loose within-doors, they still showed no fear, running about the room actively, eating freely what was given them, and, oddly enough, fighting fiercely among themselves (a habit which I never observed an instance of when they were in the open air), but never using their wing-spurs as weapons. We put several of them into an extemporized coop, where they fought and pecked at the woodwork all night, chirping the while so like chickens that I once got up, thinking that some of our fowls had been fastened into the house. When shut up in this way they bore the confinement very illy, beating themselves constantly against the bars of the cage, and pecking fiercely at the woodwork. They would often stay around the house for several days, however, when let loose, running with our chickens and feeding with them like tame pigeons. One, whose wing had been clipped, remained for a week or more, but finally wandered off and was killed by the great southern skua which fills the place of a hawk in those regions.

Cuvier,[1] on the authority of Vieillot, attributes to the larger species a propensity for carrion, and a power of erecting the horny sheath, neither of which characters was to be found in those which we observed. The Australian species (identical with *Chionis alba* of Forster[2]) was named *C. necrophaga* by Vieillot on this account, but our chionis was one of the very few birds never found feeding on carrion. It was quite omnivorous in its diet, taking with equal readiness bread, vegetables, and fresh meat. The sheath was found to be firmly soldered to the base of the upper mandible, and therefore could not possibly be erectile.

About the middle of December (midsummer in the antarctic region) the sheath-bills began to break up into pairs, and to show signs of breeding. I never was so fortunate as to find a completed nest, although I often observed the pairs frequenting the crevices of fallen rocks, as if preparing to build. By the sealers, of whom several visited the island during our stay, I was informed that they build in the localities that I had attributed to them, constructing a nest of grass-stems, and laying three party-colored eggs; moreover, that they are exceedingly dexterous in misleading the egg-hunter as to the

[1] "Animal Kingdom," London, 1849, p. 250. [2] *Vide* "Genera of Birds," Gray, *loc. cit.*

locality of their nests. The Rev. Mr. Eaton, naturalist to the English party, kindly gave me an egg which he had found on the day of our breaking up camp, January 10th, it being one of a nest of three, and evidently very fresh. It is a large egg, rather less than a hen's, pointed like a Guinea-fowl's, and marked by streaks and blotches of different shades of brown, which are said to vary much in hue in different specimens.

The sheath-bill is not only "an interesting bird" to know, on account of its trustful and familiar habits, but has been something of a puzzle to ornithologists from the time of its first description, by Forster, in 1788.[1] Up to 1841 his species, *C. alba* (*necrophaga*, Vieillot) was the only one known, and has been quite variously classified. By G. R. Gray it was placed as a member of the fifth family (*Chionididæ*) of the order *Gallinæ*, a place retained for it in the British Museum Catalogue. Bonaparte associated it with gulls and petrels, as a member of his tribe *Longipennes*, order *Gaviæ;* and De Blainville,[2] after a careful anatomical examination, decided that its nearest affinities were with the *Oyster-catchers* (*Hæmatopus*). This last decision has been accepted as final by ornithologists in general. Mr. W. K. Parker[3] thus refers to another relationship: "There are certain curious, thoroughly *marine* plovers (chionis), in which the sheathing of the upper jaw is very perfect; they thus retain a struthious character, but have it in an exaggerated condition." Were this a proper place for the discussion of osteological details, it would be easy to point out other characteristics that might show a very plausible affinity of chionis to the *ostrich!*

Not to go deeply into the troubled and doubtful sea of the various grounds of classification of birds, it will perhaps not be out of place to mention some of the principal groups of characteristics upon which we rely to determine the place in Nature of any particular bird. First, there are the external parts: bill, eyes, plumage, feet, legs, etc., relied upon almost entirely by the older writers, and likely to hold their own, because of their convenience, for a long time yet. Then there is the digestive system, indicating also some of the affinities based upon *habit.* Third, and doubtless most to be relied upon, the structure of the skeleton, particularly of the skull (Huxley) and sternum, and the variations in muscular form and attachment. Last, but by no means, in my opinion, least, the habits and behavior of the bird during life.

Considered as to externals only, we find *Chionis minor* with the general form of a pigeon, the beak of a crow, surmounted by a sheath declared to be a characteristic of the ostrich family, with stout, knobby, short legs and feet, four-toed like a fowl's, but bare for a little way

[1] "Enchiridion Hist. Nat. Ins.," p. 37.

[2] "Sur la place que doit occuper dans le système ornithologique le genre *Chionis*, ou Bec-en-fourreau," De Blainville, Ann. Sc. Nat., 1836, vi., p. 93.

[3] "Osteology of Gallinaceous Birds," "Transactions of Zoölogical Society," p. 206.

above the heel like a wading-bird. The "contour feathers" have a large downy "after-shaft," a characteristic of gallinaceous birds, and there is a thick, wattle-like caruncle on the forehead, a common feature of the swan family.

The intestinal canal presents first a large *crop*, a rather long *proventriculus* or true stomach, well furnished with tubular follicles, a decidedly muscular gizzard or grinding-stomach, and two long appendages, the cæca, all features which are characteristic of gallinaceous birds. On the other hand we find the gastric follicles large and tubular, more like those of the swan than of any other that I know of, and quite unlike the lobulated follicles of the *Gallinæ*. The tendinous parts of the gizzard, moreover, are at the *sides*, instead of before and behind as is the (almost ?) universal rule.

It would probably be neither interesting nor profitable to recapitulate here the various resemblances to and differences from other families, presented by the bony framework of the chionis. The features of the skull are pretty evenly balanced between those characteristic of the plovers and of the gulls, with a slight sprinkling of the ostrich. The breastbone, a part to which great importance is attached by ornithologists in the determination of affinities, is decidedly like that of the gull family, between which and the plovers, considering only the skeleton, the genus must probably be placed, as De Blainville has already decided. That is to say, on summing up the various osteological peculiarities which mark the skeleton of this very composite bird, the greatest number is found to lie on the gull side.

Considered with regard to habits, however, the confusion grows worse again. It looks and flies like a pigeon, croaks like a crow, "chats" like a blackbird, or (in confinement) chirps like a fowl. It lives, to be sure, upon the seacoast, and feeds largely upon small marine animals and seaweed; but it dislikes wading, becomes perfectly helpless when accidentally in the water, and has no idea of swimming. Its diet is as various as that of fowls, and like them it swallows numbers of pebbles to aid digestion. Its natural tendencies seem to be toward domestication, or at least companionship with man. Like the plants of Kerguelen, it finds its nearest relatives in Patagonia, although Africa is so much less distant. How shall we explain all these incongruities? Perhaps it represents an older, more synthetic form, from which *Gallinæ*, *Waders*, and *Gulls*, are descended, preserving its own identity by its isolated habitat. Perhaps, as the ostrich represents an ancestral type, its apparent struthious characters may indicate real relationship after all, handed down from that distant time when all birds were more nearly allied than now. Since there certainly once was a time when Kerguelen Island, perhaps then part of a continent, was habitable, when the tree trunks that are now lying buried in its northern hills were upright and flourishing forests, perhaps the men of those days had also a bird tamed, like the domestic fowl; and per-

haps the chionis is descended therefrom, and its liking for man is an inherited tendency.

Mr. Darwin exactly expressed the present attitude of this bird to science, as long ago as the voyage of the Beagle. He found a bird in Patagonia (*Thinochorus rumicivorus*) which "nearly equally partakes of the characters, different as they are, of the quail and snipe," and in this connection proceeds to remark: "A bird of another closely-allied genus, *Chionis alba*, is an inhabitant of the antarctic regions; it feeds on seaweed and shells on the tidal rocks. . . . This small family of birds is one of those which from its varied relations to other families, although at present offering only difficulties to the systematic naturalist, ultimately may assist in revealing the grand scheme, common to the present and past ages, on which organized beings have been created."

THE PROPOSED INLAND SEA IN ALGERIA.

By JOHN D. CHAMPLIN, Jr.

AMONG the most revolutionary of the geographical schemes of the day are the projects of flooding portions of the African Sahara, and thus restoring to the sea what was once an integral part of it. In the Pliocene period, according to Sir Charles Lyell, the great desert was under water between latitudes 20° and 30° N., so that the southeastern part of the Mediterranean communicated with that portion of the Atlantic now bounded by the west coast of Africa. This is indicated not only by the presence of marine shells and other remains throughout the Sahara, but also by the radical difference between the fauna and flora north and south of it. What was formerly separated by a barrier of water is now separated by a barrier of sand.

There are two principal depressions in the Sahara, the basin called El-Juf, in the Sahel, north of the Middle Niger, which covers an area of about 126,000 square miles, and that of the *shotts* in the Algerian Sahara.

Mr. Donald Mackenzie, a British engineer, who has investigated the former depression, affirms that a long valley extends from its northwest corner to the Atlantic coast opposite the Canary Islands. It is only necessary, he argues, to cut through the accumulated sands at its mouth, which is laid down on the maps as the river Belta, to let in the waters and flood the entire basin. This scheme, advocated by Mr. J. A. Skertchly, General Sir Arthur Cotton, and others, will probably result in a thorough exploration of that part of the Sahara and its alleged outlet. The other project is in a more advanced state.

The depression of the *shotts* lies at the foot of the Aures Mountains,

spurs of the main chain of the Atlas, partly in the province of Constantine in Algeria, and partly in Tunis. Its western extremity is in latitude 34° 30′ N., longitude 5° 65′ E., and it extends thence eastward two hundred and thirty-five miles to within about thirteen miles of the foot of the Gulf of Cabes, or Gabes, in the Mediterranean, anciently the Lesser Syrtis, from which it is now separated by an isthmus of sand. The breadth of the depression is about thirty-seven miles. Within these limits lie several connected lake-beds, called by the Arabs *shotts* or *sebkas*, *shott* signifying properly the bottom of a lake left dry by evaporation, and *sebka* a saline marsh. The largest of these are Shotts Melrir, or Melgig, whose eastern extremity is called Es-Selam, El-Rharsa, or Gharsa, and El-Jerid, or Fejej. About one-half is in French territory, the Tunisian boundary line cutting the western bank of Shott El-Rharsa.

This great depression is supposed to mark the site of the lake of Triton, or Tritonis, mentioned by Herodotus, Scylax, Pomponius Mela, Ptolemy, and other ancient writers, and around which were localized the Greek divinities Poseidon and Athena, and the Argonautic myth. Into it was driven the good ship Argo, when blown from her course around the Malean promontory by an adverse wind. Jason, lost among the shallows, propitiated the local divinity, Triton, son of Poseidon, by presenting him with the brazen tripod, whereupon the god, filled with prophetic heat, foretold that a hundred Grecian cities would spring up around Tritonis whenever a descendant of the Argo's crew should seize and bear away the precious gift. Through the foresight of the subtle Libyans, who hid the tripod, the prophesy was unfulfilled, but many noble cities were afterward built north and east of Tritonis, and along the coast of Syrtis Minor. Indeed, so numerous were they, and so flourishing as trade-centres, that the country was named Emporia. All the ancient writers agree in praising it for its wonderful riches and fertility. Says Scylax: "This region, which is occupied by Libyans, is most magnificent and fertile; it abounds in fine cattle, and its inhabitants are most beautiful and wealthy." It was within the dominion of Carthage, and here were the storehouses and granaries from which Rome's great rival supplied her troops.

But now all is changed. The drying up of the ancient sea has deprived the land of its moisture, and the once fertile plain between the mountains and the north bank of the *shotts* is, with the exception of a few oases, a sterile waste. Nothing remains to tell of former greatness but ruins, which are said to be scattered over the country far up into the mountains.

Herodotus, the most ancient writer by whom Tritonis is mentioned, says that it was fed by the great river Triton; but modern research has failed to identify it, there being now but a few rivulets which enter it from the mountains on the north, or lose themselves in

the desert. If there ever was a great river flowing into it, its bed has been obliterated by the shifting sands.

At a later date Tritonis appears as three connected lakes, called, respectively, Libyca, Pallas, and Tritonis, which some recognize in the Shotts Melrir, El-Rharsa, and El-Jerid. It is probable that the mouth became gradually blocked up with sand, and the lake, no longer receiving sufficient water from the Mediterranean to supply the waste from evaporation, separated into several smaller seas, which, by continued desiccation, became transformed at last into their present condition. When this took place can only be conjectured, but it was probably in the early centuries of the Christian era. The Arabs preserve the tradition that Shott Es-Selam was a lake at the time of the Mussulman conquest. They also aver that the lake bed has not been covered with water during the past hundred years.

Although it has long been known that this desert basin was lower than the Mediterranean, nothing was positively settled in regard to it until 1873, when Captain Roudaire, a staff officer of the French army in Algeria, ascertained the altitude of Biskra, and by a series of levelings from that point proved that the western extremity of Shott Melrir was twenty-seven metres, or nearly eighty-nine feet, below the level of the sea. The publication of his investigations and an exhaustive discussion of the probabilities of success in reopening the ancient lake, in the *Revue des Deux Mondes* (May, 1874), aroused interest in the project in hope not only of reclaiming the country, but also of opening a commercial avenue to Southern Algeria. The French have long sought to deflect the caravan trade of Middle Africa, which is now mostly monopolized by Morocco and Tripoli, to Algiers, but in vain, the increase in prices to be obtained in Algiers not being sufficient to compensate for the increase in distance. But with an inland sea the circumstances would be changed. The country around it would resume its ancient character of a littoral province, and the caravan routes of the Sahara would converge toward a port established on its southern border, whence the gold dust, ivory, gums, and ostrich feathers of Soodan would be shipped directly to Europe to the detriment of the Mohammedan markets. Tougourt, too, the French military post in southern Algeria, now distant nearly two hundred and fifty miles from the port where its provisions are landed, would then be only about forty miles from the sea.

Captain Roudaire discusses also the probable climatic changes which would ensue from reopening the Bay of Triton. He argues that the northwest winds, which prevail in summer, would be less violent than now, and the southwest winds, which blow during the remainder of the season, would be charged with vapor and cause a greater fall of rain in Algeria, Sicily, and South Italy, without materially modifying the climate. This increased rainfall would restore the land to its ancient fertility, and the region of the *shotts* would

again become the home of a thriving population and the granary of North Africa.

To flood the *shotts* would require only the piercing of the isthmus between El-Jerid and the Gulf of Cabes. This is about thirteen miles wide; but Captain Roudaire thinks that the curve of altitude would reach zero at about eleven miles from the Mediterranean, which would materially reduce the amount of excavation. As the evaporation would be much greater than in the Mediterranean, a large and constant flow of water from the latter would be necessary to keep it at its proper level. This would require a canal at least one hundred yards wide, which could be constructed, it is calculated, at a cost of twenty million francs. To this amount would have to be added a sufficient sum to compensate for the destruction of property in the Tunisian part of the depression, which would ensue from its submersion. Besides the towns of Nefta and Tozer, there are many douars, or villages, in the oases, surrounded by cultivated lands and date plantations. These are generally in the lowest part of the depression, for there only can potable water be found, the higher land being without springs.

The superior council of Algeria, comprehending the immense advantages which would accrue to the colony from the consummation of this scheme, voted in 1873 a sum sufficient to continue the survey, and a well-appointed expedition, under command of Captain Roudaire, made a thorough examination of the bed of the Algerian portion of the *shotts* in the following year. The French Geographical Society, taking a national as well as a scientific interest in the question, also contributed money in furtherance of the object, and deputed M. Duverrier, one of its members, to accompany the party. The expedition entered the depression on the northwest side of Shott Melrir. The soil there is sand and marl, charged with salt. The many streams which traverse the country have, with a few exceptions, no running water, excepting in winter and spring, the season of rains and of the melting of snow in the mountains. These rivers usually divide, before reaching the *shotts*, into several branches, which again subdivide and form innumerable ramifications. Where these begin to disappear, the soil, which is charged with salt and almost bare, swells and cracks, and the water sinks, when the crust reforms. Farther east are naked plains of marl, level and smooth, and covered with a white incrustation which produces frequent mirages. On the extreme west the river beds enter Shott Melrir with separating. On the south side are sand hills and moving sands.

All the *shotts* are alike in general features. All have flat bottoms with an inclination too slight to be perceptible to the eye, and all form basins which receive water-courses. The soil of all contains a great quantity of salt, which whitens their bed in dry places. But each has its peculiarities. The west end of Melrir has a bottom of sandy earth,

strewed along the borders with small round and polished quartz pebbles. Near the banks is a meagre salsuginous vegetation. In the interior its bed is clay, filled with crevices, but moist; farther on the crevices close and the saturated marl and clay form quagmires in which horse and rider might be swallowed up.

The eastern end of Shott Melrir, which is called Shott Es-Selam, presents other general characteristics. Near the banks the bed is sandy, but toward the middle it forms a hard crust of salt and sand. Elsewhere the soil is a hard surface of clay, which shines in the sun. Mirage is very frequent in this *shott*.

Between the Shotts Es-Selam and El-Rharsa the expedition first began to encounter obstacles which may seriously interfere with the projected inland sea. In the intervening country are numerous smaller *shotts*, of which that called Mouia-el-Tadjer is the largest. This shott has a long extension stretching southward, called El-Hadjila, connected with which on the east is Shott Mouia-el-Tofla. Measurements in the highest part of the bed of the latter showed it to be more than eleven feet above the level of the sea. A low ridge separates it from Shott El-Asloudg, the western border of which is only between six and seven feet below the sea, and the eastern about twelve feet. Between this and Shott Bou Dhouil, which is little more than eight feet above the sea, is an extended ridge of sand. Bou Dhouil is but a short distance from the Tunisian frontier and the great Shott El-Rharsa. At this point the expedition ceased its labors and returned to Biskra, convinced that a secondary canal connecting El-Rharsa and Melrir, or some of the *shotts* belonging to its system, would be necessary before the proposed inland sea could be extended far enough west to benefit Algeria. This would entail a considerable additional expense, but whether large enough to seriously affect the realization of the scheme cannot be known until the publication of the official reports.

This expedition made no investigation of the Tunisian portion of the depression, being evidently under the impression that no insurmountable obstacle existed in that part. Whether this belief was founded on the accounts of the ancient geographers or on an actual knowledge of the country is not apparent, but it is said that levels were taken from Shott El-Jerid to the Mediterranean several years ago by Captain Pricot de Sainte Marie, of the staff of the French army in Algeria. His report, which is deposited in the archives of the Ministry of War in Paris, must have been favorable, else the survey of the Algerian *shotts* would scarcely have been undertaken.

It is reported, however, on the contrary, that a survey was made of the same isthmus in 1874 by M. Fuchs, a French geologist employed by the government of Tunis to investigate the mineral resources of the country, who discovered that physical obstacles exist of a nature to render a canal impossible; that a range of sandstone hills lies between El-Jerid and the sea, and that the bed of El-Jerid itself is con-

siderably above the sea. If this be true, not only is the proposed inland sea an impossibility, but we must also relegate to the domain of fable the accounts of the great lake of Tritonis, or assign it to another locality.

ANIMAL PARASITES AND MESSMATES.

THE fight for a foothold in the animal world brings the combatants into many strange relations, few of which are more curious and interesting than those existing between the creatures popularly known as parasites and the animals which furnish them support. In these relations all grades of pauperism and criminality are represented. There is the miserable wretch that lives entirely at the expense of others, finding it easier to die than to help himself; the poor weakling, willing enough to do what he can, but sure to starve to death if left wholly unassisted; the petty thief that sneaks into his neighbor's premises and steals a portion of his store; and the audacious robber that boldly appropriates another's substance, and not unfrequently adds murder to his list of crimes. In his entertaining and instructive work on "Animal Parasites and Messmates,"[1] from which this article and its illustrations are mainly taken, Van Beneden makes these different degrees of dependence the basis of a rough but convenient classification, by which he separates, what have hitherto been known as parasites, into three groups, named respectively *messmates*, *mutualists*, and *parasites*.

The messmate is one that takes his place at his neighbor's table to partake with him of the product of the day's toil. He does not live directly at the expense of his host, but, abiding with him, obtains thereby better opportunities for securing a supply of food. This mode of getting a living is very common, and a curious thing about it is that animals comparatively high in the scale of organization do not scruple to quarter themselves upon others of much inferior grade. The fish known to naturalists as fireasfer lives in this relation. He takes up his lodgings in the digestive tube of a holothurian, and, regardless of the rules of hospitality, appropriates a portion of all the food that enters. He thus manages to get himself served by another better provided than he is with the means of fishing. Dr. Greef found at Madeira a holothurian over a foot long, in which one of these fishes was enjoying a peaceful and vigorous existence. Other fishes besides the fireasfer have been found in similar quarters; indeed, the situation appears a very favorable one for this mode of life, since not only fishes but crustaceans here take up their abode, sometimes in considerable numbers. Prof. Semper has seen holothuriæ in the Philip-

[1] No. XIX. "International Scientific Series," New York, D. Appleton & Co., 1876.

pine Islands which bore considerable resemblance in this respect to a hotel with its *table-d'hôte*.

A somewhat more excusable piece of pauperism is found in the case of an eel, which ensconces itself in the branchial sac of that curious fish known as the angler, or fishing-frog (Fig. 1), where he afterward plays the part of a messmate. Although the eels generally

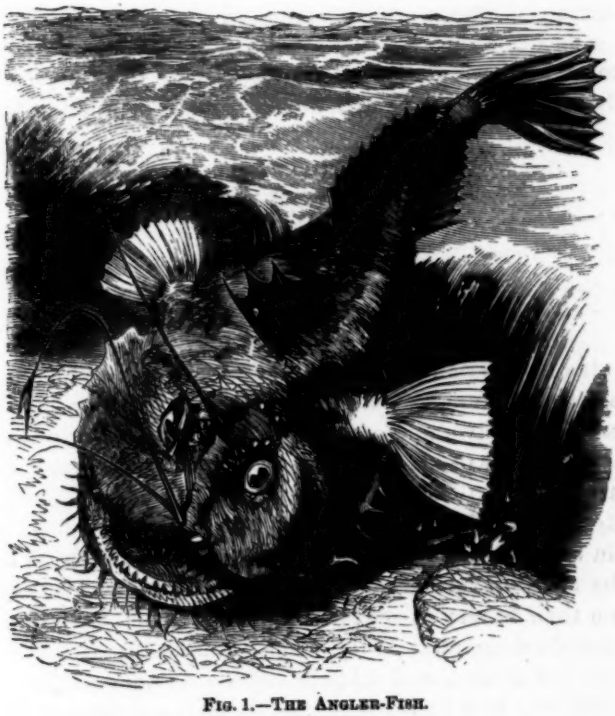


FIG. 1.—THE ANGLER-FISH.

get their living easily, the angler possesses fishing-implements which are wanting in them, and, when immersed in the ooze, it carries on a fishery sufficiently abundant for both. This relationship was first observed by Risso in the Mediterranean; the same fish in more northern seas has since been found to harbor, in like manner, an amphipod crustacean.

Another remarkable example of this kind of association among fish was made known by Reinhardt, of Copenhagen. A siluroid fish occurring in Brazil, and possessed of numerous barbules that make it successful as a fisherman, lodges in the cavity of its mouth some very small fishes, that for a long time were supposed to be young siluroids; it was believed that the mother brought her progeny to maturity in the mouth, as marsupials do in the abdominal pouch, or as some other fishes do. But this is a mistake. The supposed young are perfectly developed adult fish, that, instead of living by their own

labor, prefer to install themselves in the mouth of a neighbor, and take tithes of the morsels which he swallows.

The little crab that makes its abode within the shell of the edible oyster (Fig. 2) is a true messmate, and the oyster is but one of many bivalve mollusks that give shelter and partial support to these diminutive crustaceans. These crabs, called by naturalists *Pinnotheres*, though in one sense dependents, are at the same time of great service to the animals within whose shells they receive protection. Van Beneden says of them: "The pinnothere is a brigand who causes himself to be followed by the cavern which he inhabits, and which opens only at a well-known watchword. The association redounds to

FIG. 2.—OYSTER CRAB.[1]

the advantage of both; the remains of food which the pinnothere abandons are seized upon by the mollusk. It is the rich man who installs himself in the dwelling of the poor, and enables him to participate in all the advantages of his position. The pinnotheres are, in our opinion, true messmates. They take their food in the same waters as their fellow-lodgers, and the crumbs of the rapacious crabs are doubtless not lost in the mouth of the peaceful mussel. . . . Little as they are, these crabs are well furnished with tackle and advantageously placed to carry on their fishery in every season; concealed in the bottom of their living dwelling-place, they choose admirably the moment to rush out to the attack, and always fall on their enemy unawares. Some pinnotheres live in all seas, and inhabit a great number of bivalve mollusks."

In the examples thus far cited, and in many more that have been observed, the dependent forms are free to depart whenever they choose, and are therefore called *free messmates*. Though for a time giving up their liberty, they sooner or later resume it, in possession of all their organs for fishing and locomotion, and in all respects fitted to live an independent life. There are others, however, that enter into the same sort of association, and make the relation a permanent one: these are known as *fixed messmates*. They are free in their youth, but, as maturity approaches, and the cares of a family are thought of, a host is selected in which they establish themselves, and, throwing aside their fishing and locomotive apparatus, they renounce the world, and even part with the most precious organs of animal life, not excepting those of the senses.

[1] From Morse's "First Book of Zoölogy."

The most interesting fixed messmates are those cirripeds or barnacles which, under the names of *Coronula* and *Tubicinella* (Figs. 3 and 4), cover the skins of whales. They are, like all the rest, free while young, but later they take shelter on the back or on the head of one of these huge cetaceans, and, having once chosen their abode, are afterward permanent tenants. Each whale lodges a particular species, and

FIG. 3.—CORONET BARNACLE (*Coronula diadema*).

the manatee, marine turtles, and various sea-snakes, have also their different sorts. Others establish themselves on their own immediate relations and on other crustaceans. A pretty genus found near Cape Verd, living on the carapace of a large lobster, spreads itself over the

FIG. 4.—BURROWING BARNACLE (*Tubicinella trachealis*).

centre of the lobster's back, and looks not unlike a bouquet of flowers. Fig. 5 shows a fixed messmate attached to a sertularian.

Mutualists, as the name suggests, are animals which live on each other; and, though usually confounded with messmates and parasites, they differ from both in making some sort of return for benefits ob-

tained. Many insects shelter themselves in the fur of the mammalia or in the down of birds, and remove from the hair or the feathers the pellicle and epidermal *débris* which encumber them. At the same time they minister to the outward appearance of their host, and are of great use to him in a hygienic point of view. Animals living in the water are similarly served by minute crustaceans. These sometimes establish themselves on fishes, and, if there are no scales of the epidermis which annoy them, there are mucosities which are incessantly renewed in order to protect the skin from the continual action of the water. Among the insects found on the skins of mammals and birds that yield some return for the hospitality they receive, those belonging to the family *Riciniæ*, and commonly known as ticks, are very numerous. Among the many generic divisions, one of the most interesting has received the name of *Trichodectes;* it contains twenty species, one of which lives on the dog, another on the cat, another on the ox; in a word, there is a distinct species on each of the domestic mammals. The species infesting the dog has lately attracted especial attention, from the circumstance that it lodges the larva of the *Tænia cucumerina*, a tapeworm common to dogs. The cock, the turkey, and the peacock, carry each a distinct species of *Riciniæ*, and oftentimes several species are found on a single bird. Fig. 6 represents a form which infests the pygarg or sea-eagle.

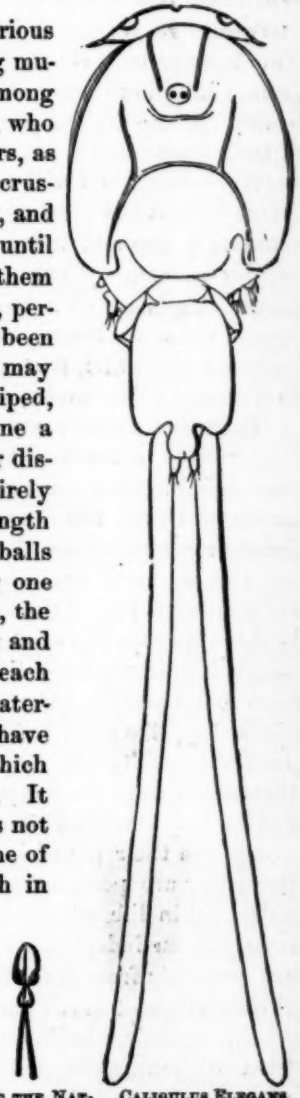
FIG. 5.—OPHIODENDRUM ABIETINUM ON *Sertularia abietina.*

FIG. 6.—RICINUS OF THE PYGARG.

Fishes harbor crustaceans instead of insects, frequently in enormous numbers. They live on the produce of cutaneous secretions, and thus, like the ticks, are of service to their hosts. The *Caligi* and *Arguli*, known usually as fish-lice, are among the most common of these, and both are elegant forms, that change but little in appearance in the course of their lives, and, although permanent tenants when once established, they retain their fishing-tackle and locomotive apparatus. The greater number of osseous fishes lodge *Caligi* on the

surface of their skin, where the tiny creatures fix themselves by means of strong cables. Fig. 7 represents a species that lodges on the cod, and it in its turn affords a resting-place for another form—the *Udonellæ*.

A curious creature, with an equally curious function, that entitles it to a place among mutualists, was discovered some years ago among the eggs of the lobster, by Van Beneden, who thus describes it: "It is known that lobsters, as well as crabs, and the greater part of the crustacea, carry their eggs under the abdomen, and that these eggs remain suspended there until the embryos are hatched. In the midst of them lives an animal of extreme agility, which is, perhaps, the most extraordinary being that has been subjected to the eyes of the zoölogist. It may be said, without exaggeration, that it is a biped, or even quadruped, worm. Let us imagine a clown from the circus, with his limbs as far dislocated as possible, we might even say entirely deprived of bones, displaying tricks of strength and activity, on a heap of monster cannon-balls which he struggles to surmount; placing one foot, formed like an air-bladder, on one ball, the other foot on another, alternately balancing and extending his body, folding his limbs on each other, or bending his body upward like a caterpillar of the *Geometridæ*, and we shall then have but an imperfect idea of all the attitudes which it assumes, and which it varies incessantly. It is neither a parasite nor a messmate; it does not live at the expense of the lobster, but on one of the productions of these crustaceans, much in the same manner as do the *Caligi* and the *Arguli*. The lobster gives him a berth, and the passenger feeds himself at the expense of the cargo; that is to say, he eats the eggs and the embryos which die, and the decomposition of which might be fatal to his host and his progeny. These *Histriobdellæ* have the same duty to perform as vultures and jackals, which clear the plains of carcasses. That which causes us to suppose that such is their appropriate office is, that they have an apparatus for the purpose of sucking eggs, and that we have not found in their digestive canal any remains which resemble any true organism."



Of the Natural Size. Caligulus Elegans. Female.
Fig. 7.

True parasites are beings entirely dependent on their neighbors for support; unable to provide for themselves, they are fed wholly at the expense of others. It is generally believed that they are an exceptional class of organisms, constituting a group by themselves, and knowing nothing of the world outside the organ which shelters them. This is an error. Representatives of all the principal divisions of the animal kingdom below the vertebrate are found pursuing this mode of life. There are few parasites that are not wanderers at some period of their lives; and it is not uncommon to find some which live alternately as noblemen and as beggars. Many are paupers only during infancy, or at the approach of adult age, living at other times a comparatively free and independent life. Nor are all the members of a species necessarily parasitic; sometimes it is only the female that takes the relation of a dependent, the male continuing his nomad life. Again, there are cases where, the female being provided for, the male relies on her for support, and thus the charitable animal which comes to her help is laid under contribution by the whole family.

Parasites present an extraordinary variety of forms, and differ very widely in size and appearance, these differences being often remarkable between the sexes of the same species. The male of the urubu of Brazil has the usual form of a round long worm, while the female resembles more than any thing else a ball of cotton, not having the slightest analogy with the other worms of the order. As to the enormous proportions parasites may attain, Boerhaave mentions a bothriocephalus 300 ells [1] in length; and, at the Academy of Copenhagen, it was reported that a solitary tapeworm (*Tænia solium*) had been found 800 ells long. Parasites are found in every region of the globe, but, like other animals, they observe the laws of geographical distribution. Some, like the leeches, take their food, and then detach themselves until the demand for food returns, never becoming identified for any length of time with their host. Others, like the lernæans, commence their parasitic existence when approaching maturity, and thereafter are permanent dependents; others, again, like the ichneumons, begin life as parasites, and on reaching maturity assume and maintain an independent existence; while still others, like the tænia, are parasitic from first to last, although changing their abode at a certain stage of development.

All animals, man included, have their parasites, which usually come from without, those entering the body being generally introduced with the food or drink. No organ is exempt from their incursions, as they have been found in the brain, the ear, the eye, the heart, the blood, the lungs, the spinal cord, the nerves, the muscles, and even the bones. Cysticerci have been seen in nearly all these situations, and worms of various kinds are common in the cavities of the body, as well as in many of the solid organs, such as the muscles, liver, and

[1] The Flemish ell is probably meant: this is 27 inches long.

kidneys. As a rule, those which inhabit a temporary host install themselves in a closed organ; in the muscles, the heart, or the lobes of the brain; those, on the contrary, which have arrived at their destination, and which, unlike the preceding, have a family, occupy the stomach, with its dependencies the digestive passages, the lungs, the nasal fossæ, the kidneys, in a word, all the organs which are in direct communication with the exterior, in order to leave a place of issue for their progeny.

A single animal may carry, not only a great number of individuals of the same species, but many different species of parasites, and this, too, without any apparent impairment of health. Indeed, in some countries their presence is considered indispensable to the highest health, the Abyssinians, for example, deeming themselves below par unless they nourish one or many tapeworms. Nathusius speaks of a black stork which lodged 24 *Filariæ* in its lungs, 16 *Syngami tracheales* in its tracheal artery, more than 100 *Spiropteræ* within the membranes of the stomach, several hundred of the *Holostomum excavatum* in the smaller intestines, 100 of the *Distoma ferox* in the large intestines, 22 of the *Distoma hians* in the œsophagus, and a *Distoma echinatum* in the small intestine. In spite of this affluence of lodgers, the bird did not appear to be the least inconvenienced. Krause, of Belgrade, mentions a colt, two years old, which contained more than 500 *Ascarides*, 190 *Oxyures*, 214 *Strongyli armati*, several million *Strongyli tetracanthi*, 69 *Tænia*, 287 *Filariæ*, and 6 *Cysticerci*. Well supplied as these animals appear to have been, when we consider the number of eggs a single worm may produce, the wonder is that parasites are not more numerous than they are: 60,000,000 eggs have been counted in a single *nematode*, and in a single tapeworm more than 1,000,000,000 eggs have been found!

While nearly all animals, including parasites themselves, are made to contribute to the support of others, those to which man gives food and lodging are of greatest interest, and he is by no means scantily provided with this class of dependents. Four different *cestodes*, or tapeworms, live in his intestines; three or four *Distoma* lodge in his liver, intestines, or blood; nine or ten *hematodes*, or round worms, inhabit his digestive passages or flesh; and *cysticerci*, *echinococci*, and *hydatids*, are also among his guests. He provides a living for three or four kinds of lice, for a bug, for a flea, and two ascarides, without mentioning certain inferior organisms which lurk in the tartar of the teeth, or in the secretions of the mucous membrane of the mouth. Some of these are confined to him exclusively, others may also find a home on the lower mammalia; some make his body their home while passing through a single stage of development, beginning or finishing the process, as the case may be, in the body of another animal; and others, again, are but day-boarders, taking their meals at his expense, and finding lodgings elsewhere.

Leeches are true parasites, although asking only food and taking care of themselves in the intervals of their meals. They suck the blood of their victim, and, when gorged to the very lips, fall off and perhaps for many weeks have no further need of assistance. The vampires of South America obtain support in a similar way, and are just as truly parasitic, although otherwise leading an independent life. The best-known leeches are those which prey on man and other mammals; but some are found which attack animals of still lower grade, especially the fishes. The organization of the leech appears always to be proportioned to that of the host which it frequents, the lower the grade of the latter the simpler the structure of the former. Those living on the mollusks are inferior to those found on fishes, and these again rank below the sorts that attack the mammalia. Fig. 8 (1, 2, 3, 4) shows the different appearances assumed by the skin after a leech-bite; Fig. 9 represents the structure of the jaws; and Fig. 10 is a longitudinal section of the body of the leech. The letters

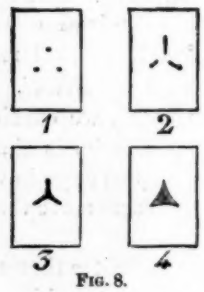


Fig. 8.

Fig. 9.

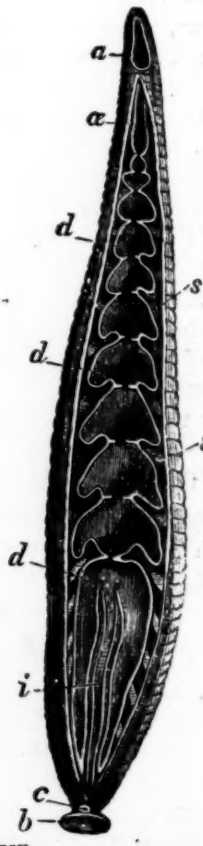


Fig. 10.

Fig. 8.—Different Forms of the Bite of a Leech.
Fig. 9.—1. Sucker, open; *a*. Jaws. 2. One of the Jaws magnified.
Fig. 10.—Section of a Leech: *a*, Anterior Sucker; *b*, Posterior Sucker; *c*, Anus; *d*, Stomach; *œ*, Œsophagus; *i*, Intestine; *s s*, Glands of the Skin.

d d d indicate the different cavities of the stomach that are successively filled when the creature feeds. These animals vary greatly in size, appearance, and mode of life. Some are exceedingly minute, and of delicate structure, while others have been seen that were a foot and a half long. Most of them are highly voracious, taking sometimes the weight of their bodies in blood at a single meal. Generally they are aquatic, but a few species are met with in the brushwood and low forest growth of the tropics, where they attack both man and beast when opportunity offers.

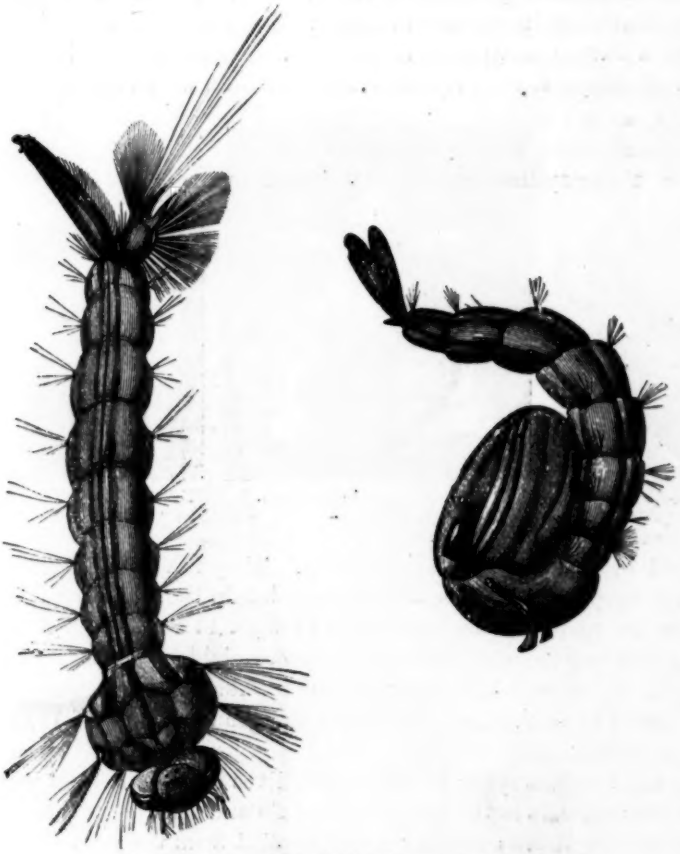


FIG. 11.—GNAT (*Culex pipiens*), LARVA AND NYMPH.

Gnats or mosquitoes are parasites that get their living in much the same way as the leeches, that is, they suck the blood of other animals, man being their most common victim. They differ from the leeches, however, in the fact that only the females are greedy of blood, the males living on the juices of plants. The females pierce the skin by means of an auger with teeth at the end, and after sucking their fill

distill into the wound a liquid venom which occasions the irritation that follows the bite. Fig. 11 shows the form of the larva and nymph of this insect. The former will be recognized as the little "wriggler" that may be seen in such numbers in stagnant water in summer. Fortunately, these insects are harmless until they acquire wings, and after that their life is a short one; but, unfortunately, they breed at an enormous rate, and thus maintain the supply, to the infinite annoyance of man and other tender-skinned animals.

Another blood-sucking parasite of both man and beast, whose staying tendencies are proverbial, is the louse. Fig. 12 represents the species that inhabits the head of man. The mouth of this insect consists of a sucker contained in a sheath, without articulations. It is armed at the point with retractile hooks, within which are four bristles

FIG. 12.—LOUSE OF THE HEAD.

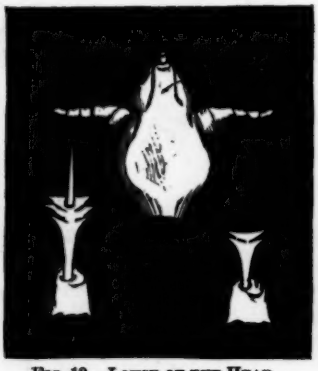


FIG. 13.—LOUSE OF THE HEAD. 2, 3, Sucker.

FIG. 14.—LOUSE OF THE HEAD, CLAW.

that aid in breaking through the skin. They have climbing feet terminated by pincers, with which they maintain their hold on the hairs. The sucker and claw are illustrated in Figs. 13 and 14. The *nits*, or eggs, hatch in five or six days after they are laid, and in eighteen days more the creature is able to reproduce its kind. Leeuwenhoek calculated that two females might become the grandmothers of 10,000 lice in eight weeks.

A not less annoying parasite that lives on the blood of man and the higher animals is the flea. Both male and female get their living in this way, and even the larvæ are supplied from the same sources by the mother, who sucks for herself first, and then divides with her young ones. The ordinary flea (*Pulex irritans*, Fig. 15) is common in both Europe and North America. It may be called a fly without wings, and, together with others of its kind, forms a distinct family under the name *Pulicidæ*. The four principal species are *Pulex irritans* of man, *Pulex cănis* of the dog, *Pulex musculus* of the mouse, and *Pulex vespertilionis* of the bat. Great numbers of human fleas, half as large as the common fly, are found in summer on the sandy

shores of the Mediterranean, in the neighborhood of Cette and Montpellier. Their presence in this locality is due solely to the circumstance that large numbers of persons of both sexes and all classes come to these places to bathe, and, laying their clothes upon the sand, leave there a part of their vermin. Van Beneden suggests the surgical employment of the flea as an homœopathic phlebotomist, and recommends this region as an excellent source of supply in case his suggestion is adopted. The largest fleas are found upon the bat; they sometimes annoy the horse, and there is a species peculiar to monkeys.

FIG. 15.—HUMAN FLEA (*Pulex irritans*).

The minute creatures known as *Acari*, or mites, are most of them parasitic, and they are very widely distributed. They are not true insects, but belong to the *Arachnida*, having four pairs of legs like the spiders, with head and thorax closely united. The group includes those disgusting creatures the itch-mites, magnified representations of which are shown in Figs. 16 and 17. The mammalia have each

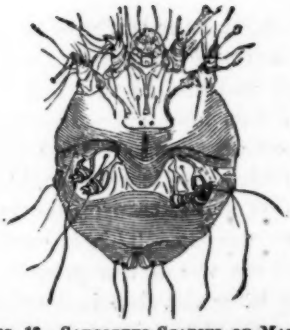


FIG. 16.—SARCOPTES SCABIEI, OR MALE ACARIUS OF THE ITCH. THE LOWER SURFACE.

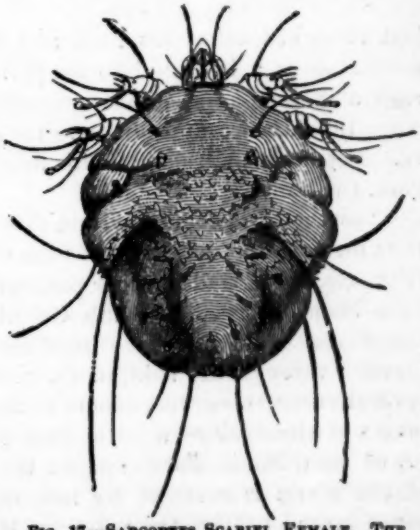


FIG. 17.—SARCOPTES SCABIEI, FEMALE. THE UPPER SURFACE.

their particular species, which in many cases are the cause of peculiar skin-affections. Since the presence of these animals constitutes the disorder, it may be easily caught; man may communicate it to the domestic animals, and they may also give it to him; it is only the genus *Sarcoptes*, however, that may be thus transferred from animals to man.

The true parasites just described, and many others like them, are nourished by the blood of their neighbors, but they never establish themselves in the organs of their host, being free throughout their lives. There is another class that live in freedom while young, but when arrived at mature age, and the cares of a family are soon to be assumed, they change in appearance, choose a host, and settle down for life. The chigoe, a parasite of man in South America, is one of these. It is only the female, however, that demands both lodging and provisions, the male (Fig. 18) being contented with pillaging his victim as he passes by. It is a small species, which pierces the shoes and clothes with its pointed beak (Fig. 19), and penetrates into the substance of the skin, generally selecting that of the toes. The male, as

FIG. 18.—MALE CHIGOE.

FIG. 19.—HEAD OF CHIGOE.

just remarked, takes his food and resumes his wanderings, but the female seeks a hiding-place for permanent abode, and then grows to such a monstrous size that the entire insect appears to be nothing more than a mere appendage to the abdomen, as may be seen in Fig. 20. Besides man, this parasite infests the dog, the cat, the pig, the goat, the horse, and the mule.

Another form coming within this category, and the terror of travelers on the coast of Guinea, is the Guinea-worm, *Filaria medinensis* (Fig. 21), also found in other parts of Africa, and said by Mitchell to have been observed in South Carolina. It was long supposed that this filaria could introduce itself into the cellular tissue of the body directly through the skin, in the form of a microscopic embryo, but several recent observers concur in the belief that it is transmitted by means of the cyclops, a little fresh-water crustacean. This is swallowed in drinking-water, and at the end of six weeks the presence of the filaria is revealed by tumors, which later develop into open sores, caused not by the worm itself, but by the dissemination of its

eggs. The filaria at last is so entirely atrophied that Prof. Jacobson, after seeing it alive on one of his patients at Copenhagen, wrote to Blainville: "This medina worm is not really a worm; it is a sheath full of eggs." In fact, all the internal organs disappear, and nothing is found in their place except the eggs and their embryos.

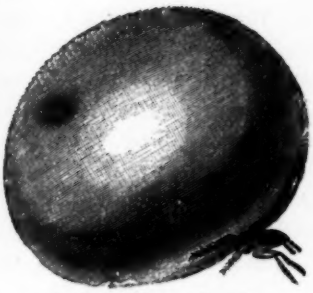


FIG. 20.—FEMALE CHIGOE.

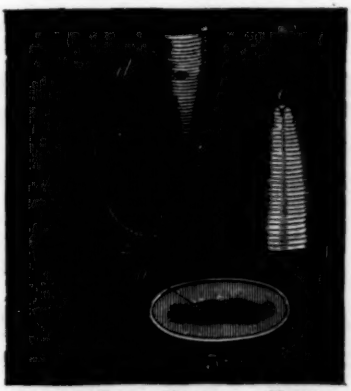


FIG. 21.—YOUNG FILARIA OF MEDINA. 1. Anterior Extremity; *c*, Mouth. 2. Caudal Extremity; *d*. Anus. 3. Section of the Body.

The ichneumons and many other insects that lay their eggs in the living larvæ of other species, belong to a class of parasites that begin life as dependents, but that become free and self-supporting on arrival at adult age. The *Œstrus*, or gadfly of the horse (Fig. 22), is

HINDER PART.

FIG. 22.—ŒSTRUS OF THE HORSE.

ANTERIOR PART.

thus dependent in its early life. But, instead of making their attacks on those of their own class, the gadflies prefer to install themselves on mammals, and sometimes even on man. The eggs are received into some cavity of the body, nostrils, stomach, or a hole in the skin, where they hatch and where the larvæ feed until the adult state is reached, when they escape and afterward live in freedom.

There is a large class of parasites generally known as worms, characterized by the circumstance that during their lives they undergo certain strange transformations that can only take place by the pas-

sage of the creature from one animal or host to another. The eggs are swallowed by some animal, usually a vegetable feeder, they hatch within its body, enter its tissues, and remain in a state of incomplete development until transferred to the stomach of another animal which has eaten the flesh of the first one. Here development recommences, and goes on to completion, when the process of reproduction begins. Each species of worm has its particular animals, through the agency of which these changes occur, and, if in its passage it gets off the proper track, that is, enters the wrong animal, it must either perish, or, as sometimes happens, find its way by a second transfer into the body of its destined host. The tape-worm of man, *Tænia solium* (Figs. 23 and 24), is a member of this group, belonging to the *Cestoidea*, or ribbon-like worms. These cestoids are found in all classes of vertebrate animals. They exist in two principal forms. The first or vesicular form resembles somewhat in appearance the finger of a glove partly drawn inward. In this shape they are always lodged in the midst of the flesh, or in a closed organ, surrounded by a cyst, and

FIG. 23.—TÆNIA SOLIUM, OR SOLITARY WORM.
a, head, or scolex; *b*, tape formed of many individuals, the last of which, completely sexual, separate under the name of *Proglottides*, and represent the adult and complete animal. Each solitary worm is a colony.

FIG. 24.—*a*, Rostellum; *b*, Crown of Hooks; *c c*, Suckers. 1. Scolex of the Tænia solium. 2. Hooks expanded; *a*, Heel of the Hook.

thus circumstanced the worm is harbored by a host which is to serve as a vehicle to introduce it into its final host. It is a parasite on a journey, and usually bears the name of *Cysticercus* (Fig. 25). In the second shape it is like a ribbon, it attains a great length, always occupies the intestine, and is mainly occupied in producing eggs, which it

turns out by the million. A description of *Tænia solium*, the most common tapeworm of man, will enable us to understand all the others. Under its first, or vesicular form, this parasite comes from the flesh of the pig, where it is often found in large numbers, when the pig is said to be "measly." This condition of the pig has been attributed to damp, to feeding on acorns, to hereditary causes, to contagion, and various other influences, but none of these notions are correct. The

FIG. 25.—CYSTICERCUS.
a, Upper Part of the Vesicle; *b*, Place where the Vesicle is about to separate; *c*, Neck of the Worm; *d*, The Head, showing the Suckers and the Crown of Hooks.

only true cause is the introduction of the eggs of *Tænia solium* into the intestines of the pig. These eggs, or fragments of tænia containing them, are swallowed by the animal. In the gastric juice of its stomach the eggs are set at liberty, lose their shells, and there issues an embryo singularly armed. It carries in front two stylets, in the axis of the body, and on the right and left sides two other stylets, which act like fins. These embryos bore into the tissues as the mole burrows in the soil. The middle stylets are pushed forward like the snout of the insectivore, and the two lateral stylets act like the limbs, taking hold of the tissues and forcing the head forward. In this manner the embryos perforate the walls of the digestive tube, and find their way, by means of the blood or otherwise, to the organ or tissue which is to become their temporary home. When arrived at this point they surround themselves with a sheath; their stylets, no longer of use, decay; and at one of the extremities appears a crown of new hooks, quite different from the former ones, which will serve to anchor their progeny in the new host to which they are ultimately destined. This vesicular worm, or cysticercus, fully formed, and without undergoing any change, waits till its host, the pig, or that part of him which it inhabits, is eaten, and, if its life has not been destroyed on its way through the frying-pan, it wakes up in some human stomach. Once there, it instantly quits its torpid state, gets rid of its useless envel-

opes, passes into the intestine, and, by means of its hooks and suckers, attaches itself to the intestinal walls, when it begins to grow with great rapidity, a length of many feet being attained in a few weeks. The part attached is the mother or head of the tænia, and until this is dislodged the worm goes on producing segments, or more properly *proglottides*, each of which is a perfect sexual being loaded with eggs. These are successively detached and escape with the evacuations, to be swallowed, perhaps, by some other pig, in whose flesh a new crop of cysticerci will soon develop. An egg of the *Tænia solium* may be swallowed by a man instead of passing into the stomach of a pig. It is hatched in his stomach precisely in the same manner, and the embryo takes up its lodging in some inclosed cavity. Some have been found in the eyeball, in the lobes of the brain, in the heart, and in the muscles. Whatever symptoms its presence may give rise to, it obviously has no chance for further progress, having selected the wrong vehicle to travel in. Man harbors not only the *Tænia solium*, but another species very similar which naturalists have only learned to distinguish from it during the last few years, the *Tænia medio-canellata*. Its cysticercus is found in beef, and is introduced when the meat is eaten in a raw or partially-cooked state. *Tænia nana* and *Tænia lata* are the names of other tapeworms inhabiting man, but both are limited in geographical distribution. The former is found only in Egypt, and the latter is confined to Russia, Poland, and Switzerland.

All these internal parasites, including the *Trichina spiralis*, which we have not space to speak of further, are introduced into the body either with the food or the drink, and a simple and effectual means of avoiding them is, to thoroughly cook the food and carefully purify the water.

PROFESSOR TYNDALL'S RECENT RESEARCHES.[1]

OBSERVATIONS ON THE OPTICAL DEPORTMENT OF THE ATMOSPHERE IN REFERENCE TO THE PHENOMENA OF PUTREFACTION AND INFECTION.

PROFESSOR TYNDALL began his paper by alluding to a former inquiry on the decomposition of vapors, and the formation of actinic clouds, by light, whereby he was led to experiments on the floating matter of the air. He referred to the experiments of Schwann, Schroeder and Dusch, Schroeder himself, to those of the illustrious French chemist Pasteur, to the reasoning of Lister and its experimental demonstration, regarding the filtering power of the lungs; from all of which he had concluded, six years ago, that the power of developing life by the air and its power of scattering light

[1] Abstract of a paper read before the Royal Society, January 18, 1876. From the *British Medical Journal*.

would be found to go hand in hand. He thought the simple expedient of examining by means of a beam of light, while the eye was kept sensitive by darkness, the character of the medium in which their experiments were conducted could not fail to be useful to workers in this field. But the method has not been much turned to account, and this year he thought it worth while to devote some time to the more complete demonstration of its utility.

He also wished to free his mind, and if possible the minds of others, from the uncertainty and confusion which now beset the doctrine of "spontaneous generation." Pasteur has pronounced it "a chimera," and expressed the undoubting conviction that this being so it is possible to remove parasitic diseases from the earth. To the medical profession, therefore, and through them to humanity at large, this question is one of the last importance. But the state of medical opinion regarding it is not satisfactory. In a recent number of the *British Medical Journal*, and in answer to the question, "In what way is contagium generated and communicated?" Messrs. Braidwood and Vacher reply that, notwithstanding "an almost incalculable amount of patient labor, the actual results obtained, especially as regards the manner of generation of contagium, have been most disappointing. Observers are even yet at variance whether these minute particles, whose discovery we have just noticed, and other disease-germs, are always produced from like bodies previously existing, or whether they do not, under certain favorable conditions, spring into existence *de novo*."

With a view to the possible diminution of the uncertainty thus described, he submitted without further preface to the Royal Society, and especially to those who study the etiology of disease, a description of the mode of procedure followed in this inquiry, and of the results to which it has led.

A number of chambers, or cases, were constructed each with a glass front, its top, bottom, back, and sides being of wood. At the back is a little door, which opens and closes on hinges, while into the sides are inserted two panes of glass, facing each other. The top is perforated in the middle by a hole two inches in diameter, closed air-tight by a sheet of India-rubber. This sheet is pierced in the middle by a pin, and through the pin-hole is passed the shank of a long pipette ending above in a small funnel. A circular tin collar, two inches in diameter, and one inch and a half high, surrounds the pipette, the space between both being packed with cotton-wool moistened by glycerine. Thus, the pipette, in moving up and down, is not only firmly clasped by the India-rubber, but it also passes through a stuffing-box of sticky cotton-wool. The width of the aperture closed by the India-rubber secures the free lateral play of the lower end of the pipette. Into two other smaller apertures in the top of the case are inserted, air-tight, the open ends of two narrow tubes, intended to

connect the interior space with the atmosphere. The tubes are bent several times up and down, so as to intercept and retain the particles carried by such feeble currents as changes of temperature might cause to set in between the outer and the inner air.

The bottom of the box is pierced sometimes with a single row, sometimes with two rows of holes, in which are fixed, air-tight, large test-tubes, intended to contain the liquid to be exposed to the action of the moteless air.

On the 10th of September the first case of this description was closed. The passage of a concentrated beam across it through its two side-windows then showed the air within it to be laden with floating matter. On the 13th it was again examined. Before the beam entered, and after it quitted the case, its track was vivid in the air, but within the case it vanished. Three days of quiet sufficed to cause all the floating matter to be deposited on the sides and bottom, where it was retained by a coating of glycerine, with which the interior surface of the case had been purposely varnished. The test-tubes were then filled through the pipette, boiled for five minutes in a bath of brine or oil, and abandoned to the action of the moteless air.

During ebullition, aqueous vapor rose from the liquid into the chamber, where it was for the most part condensed, the uncondensed portion escaping, at a low temperature, through the bent tubes at the top. Before the brine was removed, little stoppers of cotton-wool were inserted in the bent tubes, lest the entrance of the air into the cooling chamber should at first be forcible enough to carry motes along with it. As soon, however, as the ambient temperature was assumed by the air within the case, the cotton-wool stoppers were removed.

We have here the oxygen, nitrogen, carbonic acid, ammonia, aqueous vapor, and all the other gaseous matters which mingle more or less with the air of a great city. We have them, moreover, "untortured" by calcination, and unchanged even by filtration or manipulation of any kind. The question now before us is, can air thus retaining all its gaseous mixtures, but self-cleansed from mechanically suspended matter, produce putrefaction? To this question, both the animal and vegetable worlds return a decided negative. Among vegetables, experiments have been made with hay, turnips, tea, coffee, hops, repeated in various ways with both acid and alkaline infusions. Among animal substances are to be mentioned many experiments with urine; while beef, mutton, hare, rabbit, kidney, liver, fowl, pheasant, grouse, haddock, sole, salmon, cod, turbot, mullet, herring, whiting, eel, oyster, have been all subjected to experiment.

The result is, that infusions of these substances exposed to the common air of the Royal Institution laboratory, maintained at a temperature of from 60° to 70° Fahr., all fell into putrefaction in the course of from two to four days. No matter where the infusions

were placed, they were infallibly smitten in the end. The number of the tubes containing the infusions was multiplied till it reached six hundred, but not one of them escaped infection.

In no single instance, on the other hand, did the air which had been proved moteless by the searching beam show itself to possess the least power of producing bacterial life or the associated phenomena of putrefaction. The power of developing such life in atmospheric air and the power of scattering light are thus proved to be indissolubly united.

The sole condition necessary to cause these long dormant infusions to swarm with active life is the access of the floating matter of the air. After having remained for four months as pellucid as distilled water, the opening of the back-door of the protecting case and the consequent admission of the mote-laden air suffice in three days to render the infusion putrid and full of life.

That such life arises from mechanically suspended particles is thus reduced to ocular demonstration. Let us inquire a little more closely into the character of the particles which produce the life. Pour eau de Cologne into water, a white precipitate renders the liquid milky. Or, imitating Brücke, dissolve clean gum-mastic in alcohol, and drop it into water, the mastic is precipitated and milkiness produced. If the solution be very strong, the mastic separates in curds; but, by gradually diluting the alcoholic solution, we finally reach a point where the milkiness disappears, the liquid assuming by reflected light a bright cerulean hue. It is, in point of fact, the color of the sky, and is due to a similar cause—namely, the scattering of light by particles, small in comparison to the size of the waves of light.

When this liquid is examined by the highest microscopic power, it seems as uniform as distilled water. The mastic particles, though innumerable, entirely elude the microscope. At right angles to a luminous beam passing among the particles, they discharge perfectly polarized light. The optical deportment of the floating matter of the air proves it to be composed in part of particles of this excessively minute character. When the track of a parallel beam in dusty air is looked at horizontally through a Nicol's prism, in a direction perpendicular to the beam, the longer diagonal of the prism being vertical, a considerable portion of the light from the finer matter is extinguished. The coarser motes, on the other hand, flash out with greater force, because of the increased darkness of the space around them. It is among the finest ultra-microscopic particles, as the author shows, that matter potential as regards the development of bacterial life is to be sought.

But, though they are beyond the reach of the microscope, the existence of these particles, foreign to the atmosphere but floating in it, is as certain as if they could be felt between the fingers, or seen by the naked eye. Supposing them to augment in magnitude until they

come, not only within range of the microscope, but within range of the unaided senses. Let it be assumed that our knowledge of them under these circumstances remains as defective as it is now—that we do not know whether they are germs, particles of dead organic dust, or particles of mineral matter. Suppose a vessel (say a flower-pot) to be at hand filled with nutritious earth, with which we mix our unknown particles; and that in forty-eight hours subsequently buds and blades of well-defined cresses and grasses appear above the soil. Suppose the experiment, when repeated over and over again, to yield the same unvarying result. What would be our conclusion? Should we regard those living plants as the products of dead dust, of mineral particles; or should we regard them as the offspring of living seeds? The reply is unavoidable. We should undoubtedly consider the experiment with the flower-pot as clearing up our preëxisting ignorance; we should regard the fact of their producing cresses and grasses as proof positive that the particles sown in the earth of the pot were the seeds of the plants which have grown from them. It would be simply monstrous to conclude that they had been "spontaneously generated."

This reasoning applies word for word to the development of bacteria from that floating matter which the electric beam reveals in the air, and in the absence of which no bacterial life has been generated. There seems no flaw in this reasoning; and it is so simple as to render it unlikely that the notion of bacterial life developed from dead dust can ever gain currency among the members of a great scientific profession.

A novel mode of experiment has been here pursued, and it may be urged that the conditions laid down by other investigators in this field, which have led to different results, have not been strictly adhered to. To secure accuracy in relation to these differences, the latest words of a writer on this question, who has materially influenced medical thought both in this country and in America, are quoted. "We know," he says, "that boiled turnip or hay infusions exposed to ordinary air, exposed to filtered air, to calcined air, or shut off altogether from contact with air, are more or less prone to swarm with bacteria and vibriones in the course of from two to six days." Who the "we" are who possess this knowledge is not stated. Prof. Tyndall is certainly not among the number, though he has sought anxiously for knowledge of the kind. He thus tests the statements in succession.

And, first, with regard to filtered air. A group of twelve large test-tubes was passed air-tight through a slab of wood coated with cement, in which, while hot, a heated "propagating glass," resembling a large bell-jar, was imbedded. The air within the jar was pumped out several times, air filtered through a plug of cotton-wool being permitted to supply its place. The test-tubes contained infusions of hay, turnip, beef, and mutton, three of each, twelve in all. They are

as clear and cloudless at the present moment as they were upon the day of their introduction; while twelve similar tubes, prepared at the same time, in precisely the same way, and exposed to ordinary air, are clogged with mycelium, mould, and bacteria.

With regard to calcined air, a similar propagating glass was caused to cover twelve other tubes filled with the same infusion. The "glass" was exhausted and carefully filled with air, which had passed through a red-hot platinum-tube, containing a roll of red-hot platinum-gauze. Tested by the searching beam, the calcined air was found quite free from floating matter. Not a speck has invaded the limpidity of the infusions exposed to it, while twelve similar tubes, placed outside, have fallen into rottenness.

The experiments with calcined air took another form. Six years ago, it was found that, to render the laboratory air free from floating matter, it was only necessary to permit a platinum-wire heated to whiteness to act upon it for a sufficient time. Shades containing pear-juice, damson-juice, hay and turnip juice, and water of yeast, were freed from their floating matter in this way. The infusions were subsequently boiled, and permitted to remain in contact with the calcined air. They are quite clear to the present hour; while the same infusions, exposed to common air, became mouldy and rotten long ago.

It has been affirmed by other workers on this question, that turnip and hay infusions, rendered slightly alkaline, are particularly prone to exhibit the phenomena of spontaneous generation. This was not found in the present investigation to be the case. Many such infusions have been prepared, and they have continued for months without sensible alteration.

Finally, with regard to infusions wholly withdrawn from air, a group of test-tubes containing different infusions was boiled under a bell-jar filled with filtered air, and from which subsequently the air was removed as far as possible by a good air-pump. They are now as pellucid as they were at the time of their preparation more than two months ago, while a group of corresponding tubes exposed to the laboratory air has all fallen into rottenness.

There is another form of experiment on which great weight has been laid; that of hermetically-sealed tubes. On the 6th of last April, a discussion on the "Germ-Theory of Disease" was opened before the Pathological Society of London. The meeting was attended by many distinguished medical men, some of whom were profoundly influenced by the arguments, and none of whom disputed the facts brought forward against the theory on that occasion. The following important summary of these was given by Dr. Bastian: "With the view of settling these questions, therefore, we may carefully prepare an infusion from some animal tissue, be it muscle, kidney, or liver; we may place it in a flask whose neck is drawn out and narrowed in the blow-pipe-flame; we may boil the fluid, seal the vessel during ebullition,

and, keeping it in a warm place, may await the result, as I have often done. After a variable time, the previously-heated fluid within the hermetically-sealed flask swarms more or less plentifully with bacteria and allied organisms."

Previously to reading this statement, the author had operated upon sixteen tubes of hay and turnip infusions, and upon twenty-one tubes of beef, mackerel, eel, oyster, oatmeal, malt, and potato, hermetically sealed while boiling, not by the blow-pipe, but by the far more handy spirit-lamp flame. In no case was any appearance whatever of bacteria or allied organisms observed. The perusal of the discussion just referred to caused the author to turn again to muscle, liver, and kidney, with the view of varying and multiplying the evidence. Fowl, pheasant, snipe, partridge, plover, wild-duck, beef, mutton, heart, tongue, lungs, brains, sweetbread, tripe, the crystalline lens, vitreous humor, herring, haddock, mullet, cod-fish, sole, were all embraced in the experiments. There was neither mistake nor ambiguity about the result. One hundred and thirty-nine of the flasks operated on were exhibited, and not one of this cloud of witnesses offered the least countenance to the assertion that the liquid within flasks boiled and hermetically sealed swarms subsequently more or less plentifully with bacteria and allied organisms.

The evidence furnished by this mass of experiments that Dr. Bastian must have permitted errors either of preparation or observation to invade his work is, it is submitted, very strong. But to err is human; and, in an inquiry so difficult and fraught with such momentous issues, it is not error, but the persistence in error for dialectic ends by any of us, that is to be deprecated. The author shows by illustrations the risks of error run by himself. On October 21st, he opened the back-door of a case containing six test-tubes filled with an infusion of turnip, which had remained perfectly clear for three weeks, while three days sufficed to crowd six similar tubes exposed to mote-laden air with bacteria. With a small pipette, he took specimens from the pellucid tubes, and placed them under the microscope. One of them yielded a field of bacterial life monstrous in its copiousness. For a long time he tried vainly to detect any source of error, and was prepared to abandon the unvarying inference from all the other experiments, and to accept the result as a clear exception to what had previously appeared to be a general law. The cause of his perplexity was, however, finally traced to the tiniest speck of an infusion containing bacteria, which had clung, by capillary attraction, to the point of one of his pipettes.

Again, three tubes containing infusion of turnip, hay, and mutton, were boiled on November 2d under a bell-jar containing air so carefully filtered that the most searching examination by a concentrated beam failed to reveal a particle of floating matter. At the present time, every one of these tubes is thick with mycelium, and covered

with mould. Here, surely, we have a case of spontaneous generation. Let us look to its history.

After the air has been expelled from a boiling liquid, it is difficult to continue the ebullition without "bumping." The liquid remains still for intervals, and then rises with sudden energy. It did so in the case now under consideration; and one of the tubes boiled over, the liquid overspreading the resinous surface in which the bell-jar was imbedded. For three weeks the infusions had remained perfectly clear. At the end of this time, with a view of renewing the air of the bell-jar, it was exhausted, and refilled by fresh air which had passed through a plug of cotton-wool. As the air entered, attention was attracted by two small spots of penicillium resting on the liquid which had boiled over. It was at once remarked that the experiment was a dangerous one, as the entering air would probably detach some of the spores of the penicillium, and diffuse them in the bell-jar. This was, therefore, filled very slowly, so as to render the disturbance a minimum. Next day, however, a tuft of mycelium was observed at the bottom of one of the three tubes; namely, that containing the hay-infusion. It has by this time grown so as to fill a large portion of the tube. For nearly a month longer, the two tubes containing the turnip and mutton infusions maintained their transparency unimpaired. Late in December, the mutton-infusion, which was in dangerous proximity to the outer mould, showed a tuft upon its surface. The beef-infusion continued bright and clear for nearly a fortnight longer. The recent cold weather caused me to add a third gas-stove to the two which had previously warmed the room in which the experiments are conducted. The warmth of this stove played upon one side of the bell-jar, causing currents; and, on the day after the lighting of the stove, the beef-infusion gave birth to a tuft of mycelium. In this case, the small spots of penicillium might have readily escaped attention; and, had they done so, we should have had here three cases of "spontaneous generation" far more striking than many that have been adduced.

In further illustration of the dangers incurred in this field of inquiry, the excellent paper of Dr. Roberts on "Biogenesis," in the *Philosophical Transactions* for 1874, is referred to. Dr. Roberts fills the bulb of an ordinary pipette up to about two-thirds of its capacity with the infusion to be examined. In the neck of the pipette he places a plug of dry cotton-wool. He then hermetically seals the neck, and dips the bulb into boiling water or hot oil, where he permits it to remain the requisite time. Here we have no disturbance from ebullition, and no loss by evaporation. The bulb is removed from the hot water, and permitted to cool. The sealed end of the neck is then filed off, the cotton-wool alone interposing between the infusion and the atmosphere.

The arrangement is beautiful, but it has one weak point. Cotton-wool free from germs is not to be found, and the plug employed by

Dr. Roberts infallibly contained them. In the gentle movement of the air to and fro as the temperature changed, or in any shock, jar, or motion to which the pipette might be subjected, we have certainly a cause sufficient to detach a germ now and then from the cotton-wool, which would fall into the infusion and produce its effect. Probably, also, condensation occurred at times in the neck of the pipette; the water of condensation carrying back from the cotton-wool the seeds of life. The fact of fertilization being so rare as Dr. Roberts found it to be, is a proof of the care with which his experiments were conducted. But he did find cases of fertilization after prolonged exposure to the boiling temperature; and this caused him to come to the conclusion that, under certain rare conditions, spontaneous generation may occur. He also found that an alkalized hay-infusion was so difficult to sterilize that it was capable of withstanding the boiling temperature for hours without losing its power of generating life. The most careful experiments have been made with this infusion. Dr. Roberts is certainly correct in assigning to it superior nutritive power. But, in the present inquiry, five minutes' boiling sufficed to completely sterilize the liquid.

Summing up this portion of his inquiry, the author remarks that he will hardly be charged with any desire to limit the power and potency of matter. But, holding the notions he does, it is all the more incumbent on him to affirm that, as far as inquiry has hitherto penetrated, life has never been proved to appear independently of antecedent life.

Though the author had no reason to doubt the general diffusion of germs in the atmosphere, he thought it desirable to place the point beyond question. At Down, Mr. Darwin and Mr. Francis Darwin; at High Elms, Sir John Lubbock; at Sherwood, near Tunbridge Wells, Mr. Siemens; at Pembroke Lodge, Richmond Park, Mr. Rollo Russell; at Heathfield Park, Miss Hamilton; at Greenwich Hospital, Mr. Hirst; at Kew, Dr. Hooker; and at the Crystal Palace, Mr. Price, kindly took charge of infusions, every one of which became charged with organisms. But to obtain more definite insight regarding the diffusion of atmospheric germs, a square wooden tray was penetrated with a hundred holes, into each of which was dropped a short test-tube. On October 23d, thirty of these tubes were filled with an infusion of hay, thirty-five with an infusion of turnips, and thirty-five with an infusion of beef. The tubes, with their infusions, had been previously boiled, ten at a time, in an oil-bath. One hundred circles were marked on paper, so as to form a map of the tray, and every day the state of each tube was registered upon the corresponding circle. In the following description, the term "cloudy" is used to denote the first stage of turbidity, distinct but not strong. The term "muddy" is used to denote thick turbidity.

One tube of the hundred was first singled out and rendered mud-

dy. It belonged to the beef-group, and it was a whole day in advance of all the other tubes. The progress of putrefaction was first registered on the 26th of October. The map then taken may be thus described:

Hay.—Of the thirty specimens exposed, one had become "muddy"—the seventh in the middle row reckoning from the side of the tray nearest the stove. Six tubes remained perfectly clear between this muddy one and the stove, proving that differences of warmth may be overridden by other causes. Every one of the other tubes containing the hay-infusion showed spots of mould upon the clear liquid.

Turnip.—Four of the thirty-five tubes were very muddy, two of them being in the row next the stove, one four rows distant, and the remaining one seven rows away. Besides these, six tubes had become "clouded." There was no mould on any of the tubes.

Beef.—One tube of the thirty-five was quite muddy, in the seventh row from the stove. There were three cloudy tubes, while seven of them bore spots of mould.

As a general rule, organic infusions exposed to the air during the autumn remained for two days or more perfectly clear. Doubtless, from the first, germs fell into them, but they required time to be hatched. This period of clearness may be called the "period of latency," and, indeed, it exactly corresponds with what is understood by this term in medicine. Toward the end of the period of latency, the fall into a state of disease is comparatively sudden; the infusion passing from perfect clearness to cloudiness more or less dense in a few hours.

Thus the tube placed in Mr. Darwin's possession was clear at 8.30 A. M. on the 19th of October, and cloudy at 4.30 P. M. Seven hours, moreover, after the first record of our tray of tubes, a marked change had occurred. It may be thus described: Instead of one, eight of the tubes containing hay-infusion had fallen into uniform muddiness. Twenty of these had produced bacterial slime, which had fallen to the bottom, every tube containing the slime being covered by mould. Three tubes only remained clear, but with mould upon their surfaces. The muddy turnip-tubes had increased from four to ten; seven tubes were clouded, while eighteen of them remained clear, with here and there a speck of mould on the surface. Of the beef, six were cloudy, and one thickly muddy, while spots of mould had formed on the majority of the remaining tubes. Fifteen hours subsequent to this observation—viz., on the morning of the 27th of October—all the tubes containing hay-infusion were smitten, though in different degrees, some of them being much more turbid than others. Of the turnip-tubes, three only remained unsmitten, and two of these had mould upon their surfaces. Only one of the thirty-five beef-infusions remained intact. A change of occupancy, moreover, had occurred in the tube which first gave way. Its muddi-

ness remained gray for a day and a half, then it changed to bright yellow green, and it maintained this color to the end. On the 27th every tube of the hundred was smitten, the majority with uniform turbidity; some, however, with mould above and slime below, the intermediate liquid being tolerably clear. The whole process bore a striking resemblance to the propagation of a plague among a population, the attacks being successive and of different degrees of virulence.

From the irregular manner in which the tubes are attacked, we may infer that, as regards quantity, the distribution of the germs in the air is not uniform. The singling out, moreover, of one tube of the hundred by the particular bacteria that develop a green pigment shows that, as regards quality, the distribution is not uniform. The same absence of uniformity was manifested in the struggle for existence between the bacteria and penicillium. In some tubes the former were triumphant; in other tubes of the same infusion the latter were triumphant. It would seem also as if a want of uniformity as regards vital vigor prevailed. With the self-same infusion the motions of the bacteria in some tubes were exceedingly languid; while in other tubes the motions resembled a rain of projectiles, being so rapid and violent as to be followed with difficulty by the eye. Reflecting on the whole of this, the author concludes that the germs float through the atmosphere in groups or clouds, with spaces more sparsely filled between them. The touching of a nutritive fluid by a bacterial cloud would naturally have a different effect from the touching of it by the interspace between two clouds. But as, in the case of a mottled sky, the various portions of the landscape are successively visited by shade, so, in the long run, are the various tubes of our tray touched by the bacterial clouds, the final fertilization or infection of them all being the consequence. The author connects these views with the experiments of Pasteur on the non-continuity of the cause of the so-called spontaneous generation, and with other experiments of his own.[1]

The tray of tubes proved so helpful in enabling him to realize mentally the distribution of germs in the air, that on the 9th of November he exposed a second tray containing one hundred tubes filled with an infusion of mutton. On the morning of the 11th, six of the ten nearest the stove had given way to putrefaction. Three of the row most distant from the stove had yielded, while here and there over the tray particular tubes were singled out and smitten by the infection. Of the whole tray of one hundred tubes twenty-seven were either muddy or cloudy on the 11th. Thus, doubtless, in a contagious atmosphere, are individuals successively struck down. On

[1] In hospital practice, the opening of a wound during the passage of a bacterial cloud would have an effect different from the opening of it in the interspace between two clouds. Certain caprices in the behavior of wounds may possibly be accounted for in this way.

the 12th all the tubes had given way; but the differences in their contents were extraordinary. All of them contained bacteria, some few, others in swarms. In some tubes they were slow and sickly in their motions, in some apparently dead, while in others they darted about with rampant vigor. These differences are to be referred to differences in the germinal matter, for the same infusion was presented everywhere to the air. Here also we have a picture of what occurs during an epidemic, the difference in number and energy of the bacterial swarms resembling the varying intensity of the disease. It becomes obvious from these experiments that of two individuals of the same population, exposed to a contagious atmosphere, the one may be severely, the other lightly attacked, though the two individuals may be as identical, as regards susceptibility, as two samples of one and the same mutton-infusion.

The author traces still further the parallelism of these actions with the progress of infectious disease. The *Times* of January 17th contained a remarkable letter on typhoid fever, signed "M. D.," in which occurs the following statement: "In one part of it (Edinburgh), congregated together and inhabited by the lowest of the population, there are, according to the corporation return for 1874, no less than 14,319 houses or dwellings—many under one roof, on the 'flat' system—in which there are no house-connections whatever with the street-sewers, and, consequently, no water-closets. To this day, therefore, all the excrementitious and other refuse of the inhabitants is collected in pails or pans, and remains in their midst, generally in a partitioned-off corner of the living-room, until the next day, when it is taken down to the streets and emptied into corporation-carts. Drunken and vicious though the population be, herded together like sheep, and with the filth collected and kept for twenty-four hours in their very midst, it is a remarkable fact that typhoid fever and diphtheria are simply unknown in these wretched hovels."

This case has its analogue in the following experiment, which is representative of a class: On November 30th, a quantity of animal refuse, embracing beef, fish, rabbit, hare, was placed in two large test-tubes opening into a protecting chamber containing six tubes. On December 13th, when the refuse was in a state of noisome putrefaction, infusions of whiting, turnip, beef, and mutton, were placed in the other four tubes. They were boiled and abandoned to the action of the foul "sewer-gas" emitted by their two putrid companions. On Christmas-day, these infusions were limpid. The end of the pipette was then dipped into one of the putrid tubes, and a quantity of matter, comparable in smallness to the pock-lymph held on the point of a lancet, was transferred to the turnip. Its clearness was not sensibly affected at the time; but, on the 26th, it was turbid throughout. On the 27th, a speck from the infected turnip was transferred to the whiting; on the 28th, disease had taken entire possession of the

whiting. To the present hour, the beef and mutton tubes remain as limpid as distilled water. Just as in the case of living men and women in Edinburgh, no amount of fetid gas had the power of propagating the plague so long as the organisms which constitute the true contagium did not gain access to the infusions.

The universal prevalence of the germinal matter of bacteria in water has been demonstrated with the utmost evidence by the experiments of Dr. Burdon Sanderson. But the germs in water are in a very different condition, as regards readiness for development, from those in air. In water they are thoroughly wetted, and ready, under the proper conditions, to pass rapidly into the finished organism. In air they are more or less desiccated, and require a period of preparation more or less long to bring them up to the starting-point of the water-germs. The rapidity of development, in an infusion infected by either a speck of liquid containing bacteria or a drop of water, is extraordinary. On January 4th, a thread of glass almost as fine as a hair was dipped into a cloudy turnip-infusion, and the tip only of the glass fibre was introduced into a large test-tube containing an infusion of red mullet; twelve hours subsequently, the perfectly pellucid liquid was cloudy throughout and full of life. A second test-tube containing the same infusion was infected with a single drop of the distilled water furnished by Messrs. Hopkin and Williams; twelve hours also sufficed to cloud the infusion thus treated. Precisely the same experiments were made with herring with the same result. At this season of the year several days' exposure to the air are needed to produce the same effect. On December 31st, a strong turnip-infusion was prepared by digesting in distilled water at a temperature of 120° Fahr. The infusion was divided between four large test-tubes, in one of which it was left unboiled, in another boiled for five minutes, and in the two remaining ones boiled, and, after cooling, infected with one drop of beef-infusion containing bacteria. In twenty-four hours, the unboiled tube and the two infected ones were cloudy; the unboiled tube being the most turbid of the three. The infusion here was peculiarly limpid after digestion; for turnip it was quite exceptional, and no amount of searching with the microscope could reveal in it at first the trace of a living bacterium; still germs were there which, suitably nourished, passed in a single day into bacterial swarms without number. Five days have not sufficed to produce an effect approximately equal to this in the boiled tube, which was uninfected but exposed to the common laboratory air.

There cannot, moreover, be a doubt that the germs in the air differ widely among themselves as regards *preparedness* for development. Some are fresh, others old; some are dry, others moist. Infected by such germs, the same infusion would require different lengths of time to develop bacterial life. This remark applies to and explains the different degrees of rapidity with which epidemic disease acts upon

different people. In some, the hatching period, if it may be called such, is long, in some short, the differences depending upon the different degree of preparedness of the contagium.

The authors refers with particular satisfaction to the untiring patience, the admirable experimental skill, the veracity in thought, word, and deed, displayed throughout the inquiry by his assistant Mr. John Cottrell, who was zealously aided by his junior colleague Mr. Frank Valter.

MUSEUM GODEFFROY.

By Prof. HENRY A. WARD.

IN one of the quarters of the "old city" in Hamburg, untouched by the great fire of 1842, is a little square around which crowd tall, narrow buildings with high, pointed roofs. The quaint architecture, the flat barges in the canal, and the queer trucks with harness enough on each horse to stock a team of four, remind one of the middle ages; but the busy railway-station near by and the forest of shipping on the Elbe bearing the flags of every civilized nation tell us that this is the great commercial port of Northern Europe. Here lives Herr Cæsar Godeffroy, one of the merchant-princes of Hamburg, whose ships for half a century have been sailing over every ocean. His great wealth has been expended liberally and in many ways, as Hamburgers all bear witness. But in one unique method Herr Godeffroy has long been doing a great work for science in Europe—a work that has made his name honored among the *savants* of Germany. This is the originating and sustaining an immense museum, now called after his name; an establishment which has for its object the collection and distribution of zoölogical material, especially in the department of the invertebrates.

Herr Godeffroy had a deep love for the beautiful and rare in Nature, and his captains brought to him contributions from all seas. This plan he encouraged, and finally enjoined it upon them, furnishing them before each departure with nets, dredges, casks of alcohol, and other equipments for collecting largely wherever they went. Most of his ventures were among the South-Sea Islands, and thence came to him splendid crustaceans, mollusks, star-fishes, sea-eggs, holothuria, corals, sponges, sea-fans, and the like. The collection as received increased so overwhelmingly in quantity and variety (for this systematic and princely research had developed a marvelous wealth of new forms), that Herr Godeffroy determined to make it available to science in the fullest manner possible. So he gave up one of his warehouses, fitted it up from cellar to garret for the storage and handling of this material, and engaged curators to assort and put in shape for permanent preserva-

tion the fresh arrivals. Specialists were also enlisted to work up each department, identifying the old and describing the new. Thus some of the most distinguished German naturalists were employed in this great storehouse of Nature's wonders. Some of them even found here opportunities for wider comparison of species than in the Royal Museums at home.

In other cases material was sent to the highest authorities in the various classes. Profs. Kölliker and Spengel, for example, have worked up the mammals; Sharpe (of the British Museum) and Drs. Hartlaub, Finsch, and Gräffe, the birds; Prof. Peters, the amphibians; Dr. Günther, the fishes; Semper, the insects; Dunker, Monson, Martens, and Garret, the mollusks; Lütken, the echinoderms; Dr. Kirchenpauer, Kölliker, and Semper, the cœlenterates; and Dr. Ehlers, the protozoans.

This plan, most liberally sustained, has resulted in giving the Godeffroy Museum a high place among the cabinets of Europe for its many type-specimens and novelties. The duplicates were freely distributed to institutions of science in the Fatherland, and to many specialists beyond it. This munificence in thus aiding investigators is a theme of praise among professional zoölogists on the Continent. Many of the discoveries among the lower forms of marine life which have enriched German science during the last two decades may be credited to the Hamburg storehouse. Rarely have wealth and liberality been combined in a way more grateful to working naturalists; and never did science indirectly receive greater material benefit from one not himself an investigator. For Herr Godeffroy is a merchant, spending most of his time in his counting-room and at the Bourse, and superintending cargoes which unite Hamburg with nearly every part of the world. He visits his museum for an hour or two as a weekly recreation, looking over the beautiful forms, and hearing from his corps of workers their most noteworthy observations. It is a phenomenon too rare in America; nor is it common even in more intellectual Europe to find commerce and science thus sharing the attention of the same mind. A Berlin naturalist, who was in a position to know, told the writer that Herr Godeffroy had for many years in the early part of his enterprise expended not less than from six to eight thousand thalers each year in procuring and working up his natural history material. It was perhaps to lessen the burden of this outgo by an income, and to make the institution in part self-supporting and therefore more permanent, that in 1865 (?) the founder decided to offer for sale to European naturalists his stores of duplicate material already acquired and daily coming in. For this purpose a carefully-prepared catalogue of the Museum Godeffroy was issued, with a detailed list of the species in classified order, giving the author and locality, and the catalogue number which follows the specimen when it goes forth. This catalogue is in itself an almost exhaustive list of marine inver-

tebrates in the regions which the Godeffroy collectors have visited; and what gives it peculiar value is its reliable indication of the locality of the specimen, coming as it does from a trained collector sending direct to the establishment. The fifth catalogue, issued in 1874, is a pamphlet of 252 pages, and notes, in close print, the name, author, locality, and price, in Prussian currency, of about 9,600 species of insects, crustaceans, mollusks, echinoderms, cœlenterates, and protozoans, besides several hundred vertebrates. Much of this invertebrate material is in alcohol. The skillful use of this, by both collector and curator, has allowed the preservation of a large series of forms which are seldom offered for sale at a natural history establishment. Such are beautiful coral-polyps and other zoöphytes, physalias, velellas, pyrosomes, salpidæ, ascidians, holothurians, arachnidæ, minute crustaceans, polyzoöans, tunicates, and many other forms of extremest interest to the student, but heretofore rarely obtainable. In a word, the Museum Godeffroy, as now conducted, is a vast storehouse of material available for the cabinets and laboratories of working naturalists and teachers of comparative zoölogy in all parts of the world. It affords a splendid opportunity to our college professors to obtain those forms so needed in a systematic course of zoölogical lectures or in rounding out the ordinal divisions in their museums.

It may be wondered that so little has been known of this Hamburg "Zoölogical Comptoir" in America. The reason is to be found in the extreme (we had almost said unfortunate) delicacy of Herr Godeffroy, who has never been willing in any way to publish this as a commercial establishment; even the catalogue gives only on one page, accidentally as it were, the facts that the objects are for sale.

The enterprise is carried on purely in the interests of scientific discovery at a yearly expense, beyond returns, of several thousand dollars. The staff of collectors, equipped and kept in the field, is very large. Among those specially engaged at present are the following:

Herr Hildebrand is dredging in the southern part of the Red Sea and along the east coast of Africa, and interior in the Somali land, a region whose fauna is little known. Herr Dämel is at work in Eastern Australia, having passed through Queensland and penetrated three hundred miles into the interior, obtaining strange forms of mollusks and that strangest of fishes—the *Ceratodus Fosteri*. Six of these fishes, about two feet long, have been secured by him, and six German museums have got these ichthyological treasures at two hundred Prussian thalers each. Also in Australia, Frau Dietrich, a second Madame Pfeiffer, for the last ten years has been traveling and collecting for the Godeffroy Museum. Her collections of insects are astonishing in the number of new forms brought to light. In the rapturous South-Sea Islands—Samoa, Viti, Pelew, Society, Marshall, and others—Herr Kubarz and Dr. Garret have resided for more than ten years, cruising from island to island and making magnificent collections of polyps,

echinoderms, mollusks, and crustaceans. The observations of these educated naturalists are familiar to the readers of the "Transactions" of the German zoölogical societies. For a long time the discoveries of this large party of expert collectors were thus freely contributed to the various scientific publications of Germany and Great Britain. But in 1873 Herr Godeffroy commenced the *Journal of the Museum Godeffroy*, a thick quarto issued in four yearly parts. This journal contains the elaborate report of distinguished naturalists on the series of specimens submitted to them. Thus Milne Edwards, of the Garden of Plants at Paris, has described the crustaceans; and Lütken, of Copenhagen University, the echinoderms; and Dr. Günther, the celebrated ichthyologist of the British Museum, the fishes. The *Journal* is profusely illustrated with colored cuts, and takes high rank for its beauty and scientific value.

Such is the remarkable Museum Godeffroy. As a storehouse of material for the benefit of working naturalists it stands unique; and as an auxiliary to the purest, highest research, it is one of the signs of the times that wealth is not absorbed in material interests; that commerce counts it an honor to contribute to original investigation. May the number of such men increase, and such institutions multiply!

THE POLAR GLACIERS.

By C. C. MERRIMAN.

THE centre of gravity of the earth is the centre of the sphere formed by the surface of the oceans; or rather, owing to the flattening of the earth at the poles, it is a point equally distant, in opposite directions, from the level of the sea. The waters, being free to move, must of necessity conform themselves to this equidistance from the gravitating centre of the whole mass. Inasmuch, then, as any plane which cuts the earth into two parts through its centre of gravity must equally divide the weight of the whole earth, it follows also that the same plane would exactly bisect the great spheroid of the oceans. In each hemisphere the sea-level in all corresponding parts would be at the same distance from this centre; and whatever land and mountains there might be above the ocean in one half would have to be counterbalanced by land, or an excess of weight of some sort, in the other half. And this counterpoising weight must itself rise above the level of the sea, unless we say that one side of the world is composed of heavier materials than the other, of which there is not the least evidence or probability.

If the plane thus dividing the earth be that of its equator, there will be found in the northern hemisphere about 44,000,000 square miles

of land, and in the southern, so far as is known, about 16,000,000 square miles. Now, the great problem in physical geography is, What is there in the southern hemisphere to counterbalance this great excess of land in the northern?

Humboldt has estimated that, if the mountains and highlands of Asia were leveled down and made to fill up evenly the low places, the whole continent would have a uniform height of 1,150 feet above the sea. In like manner, South America would have a height of 1,130 feet; North America of 750 feet; and Europe of 670 feet. The average of the whole he estimates at 920 feet. Of the mainlands not included in the above—namely, Africa, Australia, the polar lands, and islands—about as much is north as south of the equator. So that we may safely estimate that there is in the northern hemisphere an excess of 28,000,000 square miles of land, of the average height above-mentioned, to be counterpoised by something yet to be found in the southern hemisphere.

If there is an excess in the quantity or bulk of water south of the equator over that north of it, then the difference of weight between this excess and so much land, which is about in the proportion of one to two and a half, must be added to the unknown quantity which we are soon to look for above the southern seas. As there is, of course, the same excess of water-surface south of the equator that there is of land-surface north of it, and as we may very safely assume that the oceans have a mean depth of at least 3,220 feet ($3\frac{1}{2} \times 920$) and that the southern waters average as deep as the northern, it follows that our unknown quantity is at the very least doubled by the above considerations. We have, therefore, to seek in the southern hemisphere what will balance 28,000,000 square miles of land at least 1,840 feet high.

We look over the map of the world, and down near the bottom we find some uncertain landmarks with many breaks, but on the whole tracing out very nearly the antarctic circle, and indicating that there is, covering nearly all that zone, an unexplored and scarcely discovered country. This impenetrable region is estimated to be as large as the continent of North America, about 8,000,000 square miles. A very little arithmetic will now prove the bold claim which I here make, that, even supposing the whole of this region to be land of the average continental height, there is still required over it all an average thickness of two and a half miles of solid ice to make the southern hemisphere equal the northern in weight.

This result of calculation is well confirmed by the information which all southern navigators have brought back from those most desolate and ice-bound regions. The zone of the antarctic has been encroached upon only in a small space south of the Pacific. On every other side, so far as has been discovered, mountains of ice block the way on and near the polar circle, which seems to be the great ice-bar-

rier of the south pole. Discoverers suppose what they have looked upon to be land, but rarely have they ever seen any thing but rolling ranges of ice and snow rising higher and higher as far as the eye could reach. In the most open of the south-polar seas, Sir James Ross, in 1841, sailed 450 miles along an unbroken cliff of ice from 150 to 250 feet high, and of unknown depth beneath the water. It was one of the vast antarctic glaciers pushing down into the sea, from which some of those southern icebergs were broken off, that navigators have frequently laid down for islands, while the next sailor that voyaged that way found open water where they were charted.

Not a sign of vegetation, not an indication of thawing, has ever been discovered within or near the antarctic circle, whereas there are aboriginal races and numerous settlements of civilized communities on every side within the arctic circle. The whaleboat or the dog-sledge has traversed the arctics and found the sea-level in almost every degree of high latitude. In the south no adventurer has yet penetrated within probably 1,500 miles of the centre of greatest cold. Whence comes this great difference in the climate and ice accumulations of the two poles of the earth? It is the object of this article to inquire if in the astronomical relations of our planet there are found any sufficient causes for such differences.

The path of the earth about the sun once every year is an ellipse, with the sun in one of the foci or centres. An ellipse is a circular figure having two centres instead of one; that is, the circumference is everywhere equally distant from the two centres taken together—the sum of the two distances is always the same. Therefore, the sun being in one of these centres, the earth is nearer to it in one half of the year than in the other. At the present time the nearest approach, or the perigee, occurs about the 1st day of January; and the earth is at that time 3,200,000 miles nearer to the sun than it is on the 1st day of July.

It is a peculiar property of bodies revolving in elliptical orbits, that they travel faster when near the centre of attraction than when farther away. It follows, from the second of the three great laws of planetary motion discovered by Kepler, that the line connecting the two bodies must pass over equal areas in equal times. The earth passes through our winter portion of its orbit, that is, from autumnal to vernal equinox, in eight days less time than through the summer part of it. In the southern hemisphere, of course, the condition of things is reversed, and the winter there is eight days longer than the summer. Moreover, the sun is at its greatest distance from the earth during the long southern winter, and at its least in the short northern winter.

Of the two causes, I regard the first as of main importance. Distance from the sun, whatever theory may be, does not seem to have much effect upon climate. The southern summers, when the sun is

over 3,000,000 miles nearer the earth, are said to be even some degrees cooler than the same seasons in corresponding localities of the northern hemisphere. And to take an extreme example, Mars, which is 50,000,000 miles farther from the sun than the earth is, has snow-lines about its poles which reach no nearer the equator than on our planet in corresponding seasons. But the excess or diminution of eight days, in the winters of climates which even in their warmest seasons barely balance on the thawing point of ice, is a true cause in polar conditions and differences. Considering that these days affect chiefly the period of briefest sunshine, it amounts to quite one-twentieth of the whole power of the sun on a hemisphere. This difference would not be apparent in the warm regions of the globe, where there is always an excess of heat which is carried off by evaporation and ocean-currents; but it would exert nearly its full force in polar regions which are unaffected by those influences.

It cannot be denied that it is the sun's heat which prevents the temperature of the earth from sinking to, or very near to, the absolute zero of cold, wherever in the thermometrical scale that may be. Chemists have produced a cold estimated at 257° below zero, of Fahr.[1] It is not by any means probable that this reaches the entire absence of heat. But, on the supposition that it is so, and that polar regions are unaffected by the air or water currents of the tropics, then an excess of eight winter days would lessen a polar temperature 15°, and unquestionably amount to the difference of an accumulation of ice and snow year after year, instead of the annual thawing during each summer, of the winter's increase.

This is precisely what is, or has been, taking place at the respective poles of the earth. Year after year, probably for a long period, there has been a steady accumulation of ice-material about the south pole, adding weight to that hemisphere. Then, in proportion to this increase, the centre of gravity of the earth has moved a little toward the south; and the waters, always obedient to this controlling point, have gradually gathered into the southern seas, covering the lowlands and plains of islands and continents. At the same time the waters were drawn away from the north-polar regions, uncovering lands, and leaving bays and sounds and inlets innumerable. The geography of the countries fully corresponds to these inferences. The seas of the arctics are comparatively shallow and deeply cut up, and the lands are low-lying. In the antarctics the oceans are deep and bayless, and all the mainlands and islands are precipitous and craggy, as if they were the peaks and table-lands of mountain-ranges.

It is now the question whether this state of things is a permanent arrangement—whether we of the north side are always to have the advantage of extent of territory, of fertile lands and healthful homes

[1] The temperature of stellar space is estimated by Sir John Herschel and others at —239° Fahr.

in middle latitudes, in short, of all that makes the rivalry of nations, and civilization a necessity. To answer this question it will be necessary to turn again to astronomy, and to study for a few moments some of its more abstruse problems.

In addition to the rotation of the earth on its axis once every day, and its revolution about the sun once in a year, there is also a slow, rolling motion of the equator, caused by the attraction of the sun on the excess of matter in equatorial diameters over the polar. It is precisely as when one touches the rim of a top in rapid motion: there is set up at once a slow, gyrating or tilting roll, and the upper end of the stem describes a small circle. Just so the sun lays hold of the protuberant rim of the great terrestrial top, and immediately it begins to oscillate in the long secular period of 25,868 years; while the polar axis, extended to the heavens, describes in the same length of time a small circle of 23½° radius among the northern or southern stars. This is the motion which occasions what is called the precession of the equinoxes. The plane of the earth's equator crosses the plane of its orbit; and, when the earth is at the points of junction, the days and nights are equal the world over. These two points, therefore, are the equinoxes; and the earth passes through them about the 21st days of March and September. Owing to the rolling motion of the equator, above described, these points, always in the line of intersection of the two planes, pass successively through the twelve signs or constellations, making slowly the entire circuit of the heavens. The vernal equinox, which now points to, or is on a line between, the sun and the constellation of the Fish, after about 26,000 years will have traveled the great circle of the heavens and come back again to point to the same cluster of stars which is now overhead at midnight on the 21st of March.

But the time of this revolution, so far as it affects the climate of the earth, is modified by the following circumstance: The ellipse or oblong circle in which the earth revolves about the sun is itself all the time slowly revolving. The long diameter of it—the major axis—makes a complete revolution in the heavens once in 110,000 years. Now, as this revolution is forward, or in the same direction among the constellations that the sun appears to move, while that of the equinoxes is retrograde, it follows that the extremities of the major axis, which are the perigee and the apogee, advance to meet the equinoctial points; so that the revolutions, or rather the conjunctions, of the equinoxes, which have to do with terrestrial climate, are accomplished in the shorter period of 21,000 years.

Now, all this astronomy amounts simply to this: that in the year of our Lord 1248 the earth was at its nearest approach to the sun on the 21st day of December, our winter solstice; and that in 10,500 years from that time the same thing will happen on the 21st day of July, our summer solstice. In the period comprising the first case,

our winters are short and mild, and our summers long and sunny. During the cycle which shall comprise the latter case, our winters will be rigorous and our summers short. The northern hemisphere is now having its great summer. In about 10,000 years it will be in the midst of its great winter; and whatever differences there may be between the two hemispheres, owing to astronomical causes, will then be in full force against the northern.

A distinguished Scotch mathematician, Mr. James Croll,[1] has estimated that the melting of a mile in thickness of the present antarctic ice would raise the sea-level at the north pole 300 feet, and at Glasgow 280 feet. We have calculated, from data which were intended to be under-estimates in every case, that there were at least two and a half miles of average thickness in what geographers call the great ice-cupola of the south pole. If, therefore, not only this were removed, but an equal quantity of ice were deposited at the north pole, there would be a deepening of the sea at the arctic circle of 1,500 feet.

Thus it is seen that, as certainly as terrestrial revolutions continue, in the course of 10,000 years there must come an entire reversal of polar conditions. The southern waters must be drained off to make the oceans of an opposite hemisphere. New lands, enriched with the sediment of a hundred centuries, will rise up to extend the borders of the old south continents, and islands joining together, will expand into mainlands. At the same time the northern continents must be in great part submerged, and their summits and ranges become the bleak islands and the bold headlands of a tempestuous ocean. Central Asia, with its broad table-lands, may still retain the name of a continent; but, beyond a few outlying islands, there will be no Europe, and but little of North America left. The Atlantic waters will stand five hundred feet over Lake Superior, and will wash the base of the Rocky Mountains in all their length. A new Gulf Stream may again, as it must often have done before, flow up the valley of the Mississippi, returning the deltas to the prairies, and remaking the beds of the garden of the world. These are no idle or impossible fancies. Not only are they the results of rigorous calculation, but they accord perfectly with the unmistakable evidences which the ocean has left, all over our land, of its recent work and presence.

The time-honored geologist, Sir Charles Lyell, lays great stress on the quantity of land and the configurations of continents, as chiefly efficacious in the great climatic changes. But it may be pertinently asked, What becomes of his continents and configurations when the seas of one pole advance to the other, as they unquestionably do, as they cannot but do, every 10,500 years, obedient to the transfer of

[1] This article was written before the publication of Mr. Croll's recent work on "Climate and Time." The reference here is to an article published some years since in the *Philosophical Magazine*.

vast ice-weights from one end of the world to the other? On all the mountains of New England there are sea-lines at elevations of 2,000 and 3,000 feet, and Lyell himself has recorded the facts. When the ocean was that deep over Boston, there were no continents in the northern hemisphere. Undoubtedly the height and direction of mountain-ranges, the trending of sea-shores, and the course of ocean currents, have much to do with local climates. But, instead of the relative quantity or location of land and sea having any agency in producing the glacial periods, it is these periods which produce the land and the sea.

So much for the causes and conditions which pertain to the geography of the present and the future. When, now, we turn back a few of the leaves which tell of the past condition of our planet, we immediately see that the same causes have been at work in recent geological times on a much more extensive scale—in fact, that they have been the chief agents in composing and modifying the present surface of the earth outside of the tropics. Over all the northern portions of Europe, Asia, and North America, are found the unmistakable evidences of extensive and recent ice-work. Bowlders of every size, some worn and some angular, are scattered in immense quantities over all the country, on the hills, on the plains, in places where the only possible explanation is that they were lifted up, carried, and dropped, just where they are found; and the great iceberg was the carrier. The face of the rock-beds, wherever brought to view, in the valleys or on the mountains, is almost always found to be ground or polished, and, over that, grooved and furrowed with nearly parallel scratches. The Alpine glaciers are doing exactly the same work to-day. Erratic blocks of foreign origin, and sometimes of enormous dimensions, are frequently found perched on the very tops of hills, or stranded high up the mountain-sides; and the quarries from which they came are invariably found to the northward, sometimes fifty or even a hundred miles. It is argued that nothing but polar glaciers could thus have moved them in uniformly meridional lines. The scrapings of grounding ice-floes, the marks of ancient sea-shores, and marine relics and shells, are found at elevations of several thousand feet above the present ocean-level. There is no escaping the conclusion that the northern continents have been, in not remote ages, deeply submerged beneath an ice-laden sea; and that the entire polar and north temperate regions, extending in some places south of the fortieth parallel of latitude, have been capped with one massive covering of ice of great thickness. Precisely the same evidences are found in South America, and, according to Agassiz, even much nearer the equator than in North America. We have again to search our astronomy for causes many times more powerful than any thing we have yet found, for differences of polar temperatures.

The earth is made to revolve in an orbit drawn out of the circular

form by the combined attractions of the other planets, Jupiter carrying the controlling influence. When the average of all these forces for long periods is more in one direction than in another, our planet is drawn away from the sun on that side. Now, it must occasionally happen, with the various periods of revolution of the planets, that they unite at times to produce extreme irregularities. The present difference between the nearest and farthest distance of the sun from us is 3,200,000 miles. It is found, by calculating back the planetary orbits and conjunctions, that this focal distance has been as much as 14,000,000 miles. There was, then, an excess of thirty-nine winter days during each year of the great secular winter of either pole. This exceptionally high eccentricity occurred, according to the calculations of Mr. James Croll, about 850,000 years ago. But it is now generally thought that we have no need to go back as far as that for the period of the last glacial epoch: 200,000 years ago the focal distance was 10,500,000 miles, and the winter excess twenty-eight days. This, on the supposition heretofore made of the absolute zero of cold being at least 257° below the freezing-point, would lower the mean temperature in polar regions 50° Fahr., and would unquestionably extend the permanent ice-limits far into the temperate zone. From that time, down to 70,000 years ago, the eccentricity was continually from two to four times greater than now. Since about 70,000 years ago, it has been nearly all the time less than at present. Thus it may fairly be concluded that the great glacial period of the Post-tertiary era came to an end with the fourth secular winter in the past, or B. C. 67,000.

This is a very interesting date to us of the genus *homo;* for it must have been about this time, according to all accounts, that our forefathers made their appearance on the earth. Man, with the long-haired mammoth, the woolly rhinoceros, the huge cave-bear, the great horned reindeer, and numerous other species now extinct, followed close upon the retreating ice-fields of the bowlder period. Our primeval ancestors were a race of hunters, and they subsisted on the most abundant and magnificent game that the world has ever seen. They lived in caves or under projecting ledges, and with only flint-headed weapons contested their lives and homes with savage beasts. They cracked the bones of animals for their marrow, or crushed them in stone mortars for the fats and the juices which they contained. It was the lingering carnivorous instinct to gnaw the bones of their prey. They had fires at their funeral feasts, but there is little evidence of their indulging often in the luxury of cooked meats. It was a rude life, and a hard struggle they must have had for it; but their history is read in the drift-beds and cave-deposits of Europe, as plainly as if there had been an Herodotus to write it.

The effect and bearing of the great ice periods on geological work and time will be further considered in a second article in continuation of this.

MODERN PHILOSOPHICAL BIOLOGY.

By Dr. E. CAZELLES.

TRANSLATED FROM THE FRENCH BY J. FITZGERALD, A. M.

II.

NOT all matter is capable of performing vital acts. Those substances alone possess this property which, owing to their peculiar composition, readily undergo molecular changes; that is to say, whose parts are grouped in very unstable equilibrium, and which are always ready to form other combinations. This state of instability is the result of complex combinations of six simple bodies, which at common temperatures have a very weak affinity for one another, but a strong affinity for elements outside of these combinations. Of the six, four, namely oxygen, hydrogen, carbon, and nitrogen, enter into these combinations in large proportions, while of the other two, namely sulphur and phosphorus, only a few atoms enter; and these latter elements are so readily oxidized that their presence increases the instability of the compound. Besides, the atoms of these simple bodies, though occurring in identical proportions, may be grouped according to different modes of aggregation (isomerism and polymerism), and the organic compounds which they make up stand midway between liquids and solids; their molecules are highly inconstant, whence result two well-known properties: the plasticity of organic matter, and its permeability to other substances. These properties are further causes of instability, inasmuch as they expose the organic substances to a number of disturbing influences. Thus, organic matter is not only subject to decomposition by light and heat, but also by the direct or indirect chemical action of bodies entering it, or acting on it from without. In such cases the effect of the disturbance is to cause the organic substance to pass from a state of relative instability to one of relative stability, or even to the state of compounds the most stable in the organic world.

At the same time that it undergoes the action of these external forces—and among external forces we include those developed in organized beings, but applied to other tissues than those producing them—at the same time that under the action of these external forces organic matter suffers decomposition, it becomes the scene of notable reactions. Even very inconsiderable changes in the external forces, which serve as its conditions, produce in it new molecular arrangements which offer a contrast, in their extent and importance, to the comparative insignificance of their cause. These new arrangements, being succeeded by more stable combinations, in turn bring about a disengagement of a great amount of force, in passing from

a less stable to a more stable equilibrium. The atoms of the organic substance lose part of their latent motion, which is manifested externally under the form of heat, electricity, light, nervous force, or mechanical motion, according to circumstances. Be the cause which produces these changes necessary or not, they are, of necessity, accompanied by a disengagement of force; and we can affirm of any force whatever expended by an organ of a living being, that it is the equivalent of a force acting from without upon that being. This is a consequence of the law of the persistence of force, and it may be presented under two forms: First, in order that a certain amount of force may be expended by a living being, there must have taken place, within that being, a transformation, by decomposition, of a quantity of organic substance capable of holding that force in the latent state; and, secondly, there can be no transformation of organic matter holding force in the latent state, without an expenditure of force which shall manifest itself in some shape externally.

In general terms, what we have to consider in living things is, first, a substance of special composition, and then expenditures of force by that substance; and this, too, is what we have in general terms to consider, in non-living things. The former are distinguished from the latter by the fact that the changes which constitute their history are heterogeneous; that they form many series which are simultaneous, correlative, held together by a tie of mutual dependence, the result being a high degree of complexity, a phenomenon belonging to one series having antecedents and consequents in other simultaneous series; and above all, that these changes form clearly-defined combinations. This *ensemble* of characteristics not only enables us to distinguish living from non-living things, but also to distinguish between living things themselves and to class them according to their *degree of life*. Thus a thing stands all the higher in the vital scale in proportion as, from the beginning to the end of its vital manifestations, it exhibits a larger number of successive and simultaneous changes, and as these changes are more heterogeneous and more closely linked together, and in more definite relations to one another. Between the lowest animals, rhizopods, planaria, etc., and the highest, the birds of prey, manmalia, carnivora, man, there is an enormous dissimilarity; still the definition applies to them all, and serves to define the difference which separates them, as also the difference of the numerous species lying between these extremes of the animal series.

Though this definition is a good one, inasmuch as it applies to all living things, and to them alone, nevertheless it is defective in that it omits the most distinctive peculiarity, namely, the element known as activity, in other words, those operations whereby living beings adapt themselves to their conditions of life. The definition should include the general relations of the living thing to its environment. The environment, too, has its successive and correlative changes

which, though very diverse, present no definite combinations. Its composition, no doubt, is definite, and equally so its properties; but they are variable, and its variations alter the relations of the environment to the living being. To all changes of the environment there are corresponding changes in the living being, otherwise it would perish. These changes, which follow the laws of vital changes, inasmuch as they are in a definite combination, constitute the activity of the animal; the more numerous and frequent they are, the more active is the life and the higher the rank of the living being in the scale of life. The degree of correspondence between the living thing and its environment is also its degree of life, inasmuch as in effect it connotes an increase in the number and in the mutual dependence of the vital changes which constitute life. A perfect correspondence would imply a perfect life. If to all changes of the environment there were opposed, as a counterbalance, changes in the living thing, natural death would be no more, nor death by disease or by accident, all of which are signs of a lack of correspondence.[1]

A definition of life which possesses these characters, and which expresses in a general formula the law of the changes of structure, and of the changes of function accompanying them; that is to say, which expresses the heterogeneity, the coördination, and the ever-increasing mutual dependence of these changes; and which at the same time expresses the ever-increasing correspondence which attaches them to the changes of the environment by an operation of equilibration—such a definition makes life to be an evolution, a succession of states of unstable equilibrium tending to perfect equilibrium; not

[1] We must here point out an erroneous statement made by Claude Bernard. In his article on the "Definition of Life" (*Revue des Deux Mondes*, 15 Mai, 1875, p. 345), this eminent physiologist offers as a complete definition of life a portion of Spencer's definition, as found in the "Principles of Biology." "The following definition," says he, "is proposed by Herbert Spencer: 'Life is the definite combination of heterogeneous changes, both simultaneous and successive.'" And he goes on to say: "Under this abstract form the English philosopher would specially indicate the idea of evolution and of succession observed in vital phenomena." If M. Claude Bernard had made this quotation from the "Principles of Biology" itself, he would have read immediately after this passage the following words: "This is a formula which fails to call up an adequate conception. And it fails from omitting the most distinctive peculiarity—the peculiarity of which we have the most familiar experience, and with which our notion of life is, more than with any other, associated. It remains now to supplement the definition by the addition of this peculiarity" (p. 71). Those who have studied Mr. Spencer's writings know how cautiously he sets about making a definition. He completes a formula, first expressed in very general terms, by the successive addition of essential characters, and for each of these characters he makes a minute analysis. Thus, having given as a preliminary result the formula quoted by M. Claude Bernard, Mr. Spencer adds that it needs to be completed, and a few pages further on (p. 74) he adds these words: "In correspondence with external coexistences and sequences." Again (p. 80), he writes: "The broadest and most complete definition of life will be—The continuous adjustment of internal relations to external relations." It is evident that M. Claude Bernard did not derive from the "Principles of Biology" the definition he quotes, and which he condemns. But ought he not to have taken it from that work?

only an evolution of the individual from the moment when it became more heterogeneous by the differentiation of parts and functions, but also an evolution of the *ensemble* of living beings, from the first appearance of life in its least differentiated form up to the highest degree of complexity in structure and function.

If life is an evolution, of what is it an evolution? If the question refers to an individual of any given species, the answer is easily given, for we can study the history of its life from the germinal cell to the period of its full development, and to the end of its life. But if the question refers to the *ensemble* of living Nature, only the middle portion of which is known to us, and the beginning of which we have no idea of save in imagination, then the reply must be only an hypothesis. We find groups differing from one another by their respective degrees of vital evolution, and we regard them as being, not as it were links of one chain, but rather the result of an evolution which has taken different directions owing to different circumstances. Hence we can admit only one starting-point, though the goals are many. The divergent lines which we find in the development of the forms of living things, in the history of life, warrant our supposing the starting-point to be one, and at this point the evolution hypothesis must place the formation of primordial organic matter, whose reactions with its environment present the first crude examples of vital function.

The hypothesis which accounts for the production of life by the spontaneous generation of a complete organism from simple protoplasm is irreconcilable with evolution; this would suppose something more than an evolution, in fact a *beginning* in the absolute sense, an enormous hiatus between the causes and their supposed effects. But on the theory of evolution we can conceive of another mode of formation. It is possible that even now, under existing cosmical conditions, organic matter is produced; but it is more probable that it was formed in an epoch when the cosmical forces now known to us, especially heat and light, had on earth a greater intensity than at present. The first types must have been more simple, less definite, less fixed in form and structure, than the lowest rhizopods of our day. Indeed, they must have been more nearly allied to protoplasm than even Haeckel's *Protogenes;* and, before evolution could derive from these types our present infusoria, ages and ages must have elapsed. Strictly speaking, we cannot call the first living thing an organism at all, in the true sense of that term; it is stretching the meaning of words to speak of types in connection with beings whose form must have been perfectly unstable, and whose organization had no structure.

Of this quasi-organism we have merely a symbolic conception, formed by combining two positive, empiric elements, viz., transformations of substances strictly evolutive, such as we see in the laboratory

of the chemist, where organic matter goes through a series of gradual modifications by which it is adapted to new artificial conditions; and, on the other hand, facts observed in the lowest orders of animals by the biologist. We conceive that, in the primordial world, as now in the laboratory, higher types of organic substance were formed at the expense of lower types, and that gradually, after repeated reactions and under favorable conditions, they resulted in organizable protoplasm, a substance which is very susceptible of modification. Protein, as we know, may exist in upward of one thousand isomeric forms, and, by combination with itself and with other substances, it yields products still more complex, and in countless numbers. Hence we can easily conceive how, under the conditions of heat and light then existing on earth, and with the aqueous, mineral, and atmospheric environment of that epoch, protein may have undergone metamorphoses without end. Under conditions which we can conceive as possible, though we may not be able to define them exactly, products may have been evolved fitted to exhibit the rudimentary vital reactions. In this way we fill up the chasm which divides the positive chemical facts of the higher organic combinations from the biological phenomena of the lower forms of life.

But another hypothesis is still necessary. "When we come down to the substances out of which living bodies are formed, we find groups and sub-groups of manifold and divergent compounds, the units of which are large, heterogeneous, and unstable in a high degree. Why should we suppose that these combinations must stand still at the complex colloids which enter into the composition of organic matter? Is it not more probable that, in addition to these colloids, there are developed by a higher combination atoms still more heterogeneous and compounds still more numerous? If colloids are unstable, extremely modifiable by very slight incident forces, and incapable of assuming the equilibrated form of crystallization, then *a fortiori* these new organic atoms are unstable, very modifiable, and of many different species." They would surpass protein in instability and plasticity as much as protein surpasses organic matter. Furthermore, these atoms would possess one fundamental property, without which no explanation is possible in biology, viz., the property of arranging themselves in certain forms peculiar to the various groups to which they belong—a property but little understood, though its existence is unquestionable. We call it *polarity*, for want of a better term, to indicate the power of manifesting actions in a certain fixed direction. These atoms we denominate *physiological units*. They are developed in every living thing, differentiating themselves from one another in different organisms by the same causes which differentiate the organisms themselves, and in this way acquiring a diversity which corresponds to that of the creature they constitute by their aggregation. They follow, step by step, in their modifications the modi-

fications of the aggregate to which they belong. They undergo the influence of the environment, though indirectly, through this aggregate. Their modifications are new directions, amplitudes of new vibrations, which place them in equilibrium with the forces which the *ensemble* of the aggregate, as modified by the environment, brings to bear upon them. These modifications endure as long as equilibrium endures, and are ever transmitted to the new units which spring from the former ones, until, on the equilibrium being disturbed, a new breaking-up of the existing relations necessitates others.

The hypothesis of physiological units is a necessity, not only in order to fill up the gap which separates the highest products of organic chemistry from those irreducible elements revealed by the microscope which we call morphological elements, but also in order to furnish a substratum for the positive property which serves to account for the great facts of biology, and to refer them, by formulæ expressed in terms of mechanics, to first principles.

Let us now consider the great facts of biology.

The *growth* of an organism is an operation essentially like the growth of a crystal. "Around a plant there exist certain elements that are like the elements which form its substance; and its increase of size is effected by continually integrating those surrounding like elements with itself. Nor does the animal fundamentally differ in this respect from the plant or the crystal. Its food is a portion of the environing matter that contains some compound atoms like some of the compound atoms constituting its tissues; and, either through simple imbibition or through digestion, the animal eventually integrates with itself units like those of which it is built up, and leaves behind unlike units."

Organic growth differs from inorganic in this, that it has limits. All conditions remaining the same (a proviso that must always be made in biology), and the quantity of integrated substance not varying, we find that, by the principle of the persistence of force, the growth of the living being must depend on the expenditure. The only portion of the integrated substance that can serve for growth is the unexpended residue, the excess of nutrition over expenditure—a quantity which is essentially variable, and which transfers its variations to the growth, limiting it and diminishing it more or less rapidly from the moment when the body of the living thing has attained its full development. Experience shows that the limit of growth is fixed for those organisms which have large expenditure, and that for those which have hardly any expenditure this limit gradually recedes; of this the crocodile is an instance. But there is another element which must be taken into account, namely, that the definitive volume of an organism, being the sum of its initial volume and of its successive increments, must depend upon the initial volume. The definitive vol-

ume depends also on the organization, which enables the living thing to assimilate substances in large quantity and to dispose of an amount of nutrition in excess of the expenditure, just as a large capital, while it gives the means of undertaking great enterprises, at the same time yields increased profits.

The integration by an organism of substances homologous with its own has for its effect a segregation which increases the difference between the organism and the environment, and at the same time makes this difference stable. While the organism is being integrated, at the expense of the environment, by deriving from it special materials, each organ is being integrated at the expense of the organism, from which it derives, as from an environment, its special materials. Like the organism, each organ diverges more and more, by a gradual segregation, from the organs around about it. The organic units which constitute it attract other units with the same polarity, diffused throughout the fluids. This is not always the case, and homologous units do not always exist ready made in the nutrient fluid. More generally the organic units find in the fluids only the elements necessary for the production of homologous units, and segregation is perfected by a phenomenon of the nature of a genesis. Still in this case, as in the preceding, the result is a more perfect differentiation of the parts of the organism, an increase of heterogeneity, and augmentation of the distinction between the different parts, and ultimately the formation of a structure and of an actual organism. This result is called *development.*

Expressed in general terms, development is the transition from a state of incoherent homogeneity to a state of coherent and definite heterogeneity; from a state wherein the parts are all alike, or rather, where there are no distinct parts, to a state wherein there are parts clearly defined, with fixed forms and attributes. The bud of a plant consists of a hemispherical or subconical projection which, at its apex especially, is made up of a transparent mass of cells not yet organized into tissues. This mass grows owing to the rapid multiplication of the cells, lengthens, sends forth other similar projections having a like homogeneous structure; from this come leaves. As the branch develops, the cells, which at first were identical, assume different characters, till at last they lose all resemblance to one another. The same thing takes place in man. His arm is at first simply a little budding prominence on one side of the embryo, consisting of simple cells without any signs of arrangement. Soon there appear vessels, and later the cartilaginous parts from which are produced the bones, the gelatin-like bands which afterward are transformed into muscles, etc. In the individual we see the first phase of existence characterized by a state of homogeneity wherein nothing is distinct, and we follow step by step the gradations of its transition to a greater complexity, and to states characterized by increasing distinction of parts, as their dissim-

ilarity becomes greater. And what is true of the individual animal or plant is equally true of the whole organic world. Baer's law would lead us to suppose that the organic world has developed like the individual; that, starting from homogeneity, it has resulted in heterogeneity. In the early stages of their existence, all organisms are alike in most of their characters; somewhat later their structure resembles that found at the corresponding period in a smaller group; at each subsequent stage the organism acquires traits which distinguish the developing embryo from one after another of the groups which before it resembled; till finally the class of organisms which it resembles includes only the species to which the embryo belongs. Thus, in the process of differentiation, the embryo first acquires those characters which determine the *sub-kingdom* to which it belongs, then the *class*, then the *genus*, finally the *species*. In the series of organisms we should thus find a succession of states like those which constitute the history of the individual, with this difference, that in the individual we can make out the link which connects the primitive homogeneity with the final heterogeneity, while in the series of organisms all we can do is to connect, with a considerable degree of probability, the hypothetical starting-point with the positive goal.

Side by side with heterogeneity and distinction of parts in the structure, we have a correlative result of this same segregative operation, viz., differentiation, which tends to produce heterogeneity and distinction of functions. The expenditure of the force that is stored up in the shape of materials takes place through the parts of the organism, however little heterogeneous these may be supposed to be, and this force is in fact for the parts an incident force which, by the law of the multiplication of effects, must break up in the process of differentiation, when applied to heterogeneous parts. The functions are simply the variously-modified forms assumed by the forces disengaged by the organism as they traverse specialized parts; and, the more diversified the organs, the more diversified are the functions they manifest. Of these some may be denominated static, inasmuch as they serve only to withstand external forces by equilibrating them; such, for example, are the functions of the woody axis in plants and of the skeleton in the vertebrata; others may be called dynamic, as producing motion and giving it direction; such, for example, are the functions of the circulatory apparatus and its belongings in both kingdoms of the organic world, and of the muscular apparatus in animals.

Like structure, function obeys the law of evolution; it proceeds from the homogeneous, the undefined, the incoherent, to the heterogeneous, the definite, the coherent. Like structure, function proceeds from the simple to the composite, from the general to the special. An important corollary results from this law—one that settles the dispute which has so long divided physiologists upon the question as to which precedes the other, function or structure. If the starting-point

be homogeneity, and if the transition from a structureless to a structural state is a phenomenon of vital action, then vital action precedes structure. Life is a system of internal actions adapted to equilibrate external actions; actions are the substance of life, its form comes from structure. Hence action must of necessity precede the fixation of the structure, which produces the adaptation and gives definite form to the function. From first to last, function is the determining cause of structure. But in justice to those who maintain the precedence of structure, it must be added that function, which, as we hold, is anterior to structure, nevertheless, regarded as an activity modified and different from what it was, assumes its differential, distinguishing characters only in proportion as the adaptation becomes perfect, and as equilibrium is established between that portion of internal reaction which it represents and the external action which it withstands.

At first there are only two functions, corresponding to the structural distinctions of endoderm and ectoderm, viz., the functions of accumulation and of expenditure of force. In proportion as each of the apparatus and each of the corresponding functions become differentiated and subdivided into specialized parts, a third function appears and takes root; at first this is a very simple affair, and it employs an ill-developed apparatus, but gradually it becomes more complex, and ultimately, in the higher animals, is divided into very definitely specialized parts. This is the circulatory apparatus, which performs those operations whereby materials containing latent force are distributed throughout the organism.

But differentiation is not the only change produced in the organism. The functions, as they multiply and are better defined, combine, become dependent on each other, are *integrated.* Labor is divided, as they say in political economy, but it is also centralized, and coördinated. Alongside of division of labor we have coöperation: an organ does not work for itself alone; it has a special function, but this function serves to facilitate, or even to render possible, the special function of some other organ.

As the formation of an organ depends on the function, so the growth of an organ depends on the growth of the function, and when once produced it is maintained only when the increase of function persists. And not only its growth, but also its development (including the differentiation of structure which accompanies it), depends on the development of the function, or, in other words, on the differentiation of the reactions of the organism to the forces of the environment.

We shall all the better understand the mechanism of the adaptation and of the modifications produced in one another by function and structure, if we consider what must of necessity occur when an augmentation of function in an organ answers to an augmentation of the demand for work made by the external conditions. In virtue of the law of universal rhythm, the result of excess of function is excess of

wear, and consequent relative impotence of the organ. Thus excess of function in the organ A cannot go on forever unless the losses are constantly made good, the wear compensated, its power renovated; and this cannot be without an augmentation of function in one or more organs, B, C, D, etc., on the activity of which its own activity depends. The increase of function in these organs once established by a definite structure, the organ A not only can preserve its increase of structure and function, but it has now a firmer basis for growing still more, for producing another excess of function, and for going farther in the same direction than otherwise it could have gone. But adaptive modifications have a limit, and it is always near at hand, though it slowly retreats from generation to generation. This we learn from the mechanism of adaptation. As the function of an organ cannot be permanently increased save on condition that the functions of those organs on the action of which it depends have gained a permanent increment, and as they in turn are conditioned on a permanent increment in the functions of other organs, it is plain that there is needed nothing short of a reconstruction of the whole organism upon a plan which shall insure normal provision for the organ that is subject to an excess of function, and in which this excess of function shall be in fact a normal process. If equilibrium be disturbed at one point, it is reëstablished only by propagating its own disturbance to all the internal equilibria; and, in order that it may itself endure, it must not be disturbed by a perturbation of reaction from within; the internal equilibria must be restored at the expense of the forces developed by the nutrition, and must be fixed by modifications of structure.

So long as this rearrangement of the internal equilibria remains unconsolidated by a reconstruction of the general structure, so long will the equilibrium produced by the adaptive modification, at the point affected by the initial disturbance, remain instable. And if, now, the disturbing conditions from without cease to exist, then the new structure, no longer sustained, so to speak, by an excess of temporary function, and receiving from the auxiliary organs, which are not yet adapted to this service, no permanent excess of function, can only furnish the same amount of action which it furnished originally. Little by little the imperfectly modified parts return to their original functions, and the whole scheme of adaptation comes to naught. Thus we see that, in virtue of the general laws set forth in the "First Principles," an adaptive change must quickly find a term beyond which it cannot progress save slowly—a fact which explains the apparent fixity of species, or the inconsiderableness of such deviations from a type as can occur during the periods over which our observations extend. It is plain that a modifying cause, the action of which persists only for a short time, can produce only a transient modification; that the complexity of the internal equilibria and their reciprocal dependence constitute the one great obstacle to the per-

manent change of structures and functions; that a disturbing influence, even though it were to extend to many generations, can only modify a race superficially; and, finally, that, the instant that this cause ceases to be, the race resumes, slowly but surely, its original characters.

In fact, the environment is ever changing, and in the enormous cycles of changes in the conditions surrounding organic life upon the earth the same conditions have never occurred a second time. Organisms must follow this movement of variation; they must be ever undergoing a process of adaptation, in order to be in equilibrium with the altered conditions around them. In this necessity for adaptation we recognize a consequence of our first principles. The state of homogeneity must give way to a state of heterogeneity: a species must be ever growing more and more varied in its forms; old species must be ever breaking up into new. If at one time a species consisted of individuals alike in all respects, the action of the various forces of the environment would soon put an end to this uniformity; at the same time, however, leaving tokens of relationship. But let us go further, and suppose the conditions to be still more profoundly altered, owing, for instance, to a climatic perturbation of the habitat, or to an emigration of the species into other habitats; in that case there will be different sets of conditions, and the groups of individuals will resemble one another, or be unlike, according to the likeness or unlikeness of the conditions. The connection between changes in the conditions, changes in function, and changes in structure, is a consequence of the persistence of force.

The law of heredity, which is antagonistic to the law of variation, may also be traced back to our first principles. This law represents the element of fixity in the domain of life. All the organisms of a given type are descended from organisms of the same type. If we consider heredity in a succession of organisms, it appears to be inexplicable. Many still deny the existence of heredity, and explain the resemblance of the child to its parentage by a special intervention of the creative power of Nature. But, if we compare the heredity of the individual with certain phenomena occurring in the individual, for example, the repair of tissues, the reproduction of worn-out or lost parts—a process which in some animals goes so far as to reproduce highly-complex organs or groups of organs (for instance, in lizards, the reproduction of feet and tail; the reconstruction of the fresh-water hydra; the restoration of the plant *Begonia phyllomaniaca* from a fragment of its leaf)—we shall perceive that there exists a tendency to reproduce like products, and that the two orders of phenomena are related. We must suppose them both to be due to the tendency of the physiological units of an organism to arrange themselves in the form proper to that organism. But we need not recognize in this tendency any such mystic entity as an *Archæus* or a *vital*

principle. Sound philosophy should discredit all such fanciful ideas. The tendency merely signifies that these polarities, being complexes of the physiological units, can find equilibrium only in the form of the adult organism to which they belong. To this equilibrium they tend, not only by an internal impulsion, but also under the combined action of external forces: the latter represent the force which arranges the units in a new order, and the former the direction in which this force is exerted. Now, the cells which go to reproduce an organism are in a state of unstable equilibrium and of minimum heterogeneity: but they are not indifferent substances; they are the vehicles of physiological units derived from the parents, and they follow only the tendency impressed upon them by their polarities. The same is to be said of the elements of the plasma from which a tissue or an organ is reproduced. Thus we see that the resemblance of an organism to the organisms from which it is sprung is the result of the tendencies proper to the physiological units which have come from the parents.

In the fecundated germ there are two groups of physiological units, presenting in their structures slight differences, so that by their fundamental resemblance they conspire to form an organism of the species to which the parents belong, and by their differences they give to this organism traits peculiar to each of the two parents. In this way, simultaneously with transmission of generic and specific characters, we have transmission of those which are peculiar to the individual. Further, we see that characters due to variations called accidental or spontaneous, because we are unable to assign their true cause, must also be transmitted as a tendency of the physiological units, provided this character has gained in the individual such a degree of stability as henceforth to find its place in that individual's state of equilibrium. The action of the surrounding conditions will determine whether the tendency of the physiological units is to be realized or frustrated. The tendency of the physiological units expresses an internal equilibrium, and hence heredity is a consequence of our first principles.

One character of living things is the faculty of reproducing themselves, i. e., of emitting parts of themselves which develop into perfect individuals. This property, in all respects analogous to that which reproduces tissues, differs from the latter only as regards the production of new individuals, or only parts of the same individual. There is an analogy between the operation of generation and that of repair, but there is also a difference. In repair the new products are aggregated around the same axis as the old, whereas in generation the new product soon becomes itself the axis around which the increments of nutrition group themselves. In reality, the contrasts are in excess of the analogies; generation is at bottom an operation of disintegration. This is very well seen in those low organisms which produce

new generations by fission, and abdicate their individuality in favor of a greater or less number of new individualities. It is also to be seen in those organisms on whose surface a new organism is formed by the process of budding. Here the disintegration is perfect, or nearly so, but in the higher organisms the disintegration affects only an insignificant portion of the parent.

Why this special disintegration? Biology can give no answer, unless we suppose that the genesis of individuals belongs as a genus to a class of facts including all the phenomena of general disintegration which attend growth, and which mark the gradual decline of the organism. This supposition finds its warrant in the fact that, as a general rule, reproduction does not take place until growth and structural development approach their term, when the molecular forces of the physiological units find themselves in equilibrium with the forces of the organism as a whole, and with the forces from without. Disintegration would now set in, or, to speak more exactly, disintegration would now begin to show an excess over integration, for, ever since the earliest vital phenomenon, disintegration has constantly accompanied integration. Among the various modes in which the decline of the organism is gradually brought about, there is one which resembles all the others, inasmuch as it constitutes a loss to the individual, but which differs from them in that it gives rise to new organisms. In a large number of cases among individuals of the lower orders of organisms, units combined in a certain group, and carrying away with them, as we have seen, their own proper tendency to find the equilibrium of their forces in arrangements similar to those in which they were originally integrated, become detached, and form the centre of a new integration. But in a very large number of organisms, and in all higher organisms of both the organic kingdoms, reproduction takes place by the mixture of two products, the one germinal, the other spermatic, coming from slightly different physiological units. In virtue of a property found in the simplest organic elements, and still more markedly present in the complex organic elements of living things, the mixture of substances which differ little from one another gives rise to products that are less stable than their constituent elements. Accordingly, the result of this mixture, namely, the fecundated germ, is farther from the state of equilibrium than were the units emitted by each of the parents, in the shape of germinal and spermatic cells. The faint tendency which existed in each of these groups to produce evolutional phenomena is intensified with the instability of the mixture. From this we may infer, if not the impossibility, at least the difficulty of an agamic genesis, and the necessity of a genesis by concurrence of different sexes. This conclusion, derived from the law of equilibrium, which itself flows from the law of persistence of force, seems to be hardly in agreement with facts, since unquestionably there exists such a thing as agamic gene-

sis. But agamo-genesis is not habitual in organisms of very simple structure, which exhibit the first steps in evolution, and in which the absence of highly-specialized tissues shows that integration still possesses its full intensity, and is far removed from equilibrium. Besides, those more complex organisms which exhibit the phenomenon of agamo-genesis, from time to time reproduce by way of gamo-genesis. After a series of agamic generations, the units of the organism will find themselves in an attitude approaching that of mutual equilibrium. The groups of units emitted as germs will no longer be able to assume arrangements which shall give them the form proper to their species, and agamo-genesis will be impossible, or very difficult. The series would come to an end did not sexual generation intervene periodically, restoring a state of instability, which gives back to the organism the power of evolution. Another conclusion, which at first sight appears to contradict the facts, is this, that an organism needs, in order to reproduction, the concurrence of another organism differing slightly from it. This is true of the higher organisms; but lower down in the animal scale, and in most phanerogamous plants, hermaphrodism is apparently the rule. But, not to speak of the fact that most frequently fecundation takes place in monœcious organisms by the intervention of another individual, so that such authors as Huxley and Darwin regard this intervention as the law of reproduction, the hypothesis which we maintain affords an explanation of hermaphrodism in those exceptional cases where it appears to exist beyond question. On the same principles which account for the variable results of the union of near kindred, we can understand how, in the case of hermaphrodites, there may exist simultaneously groups of physiological units coming from each parent, keeping their proper tendencies, which find only partial equilibrium, permitting one or other side to be in excess, and there undergoing the operation of segregation, which produces groups so differentiated that fruitful germs result from their mixture.

Considered in the light of this hypothesis, generation appears as a fact of disaggregation, occurring in an organism in process of equilibration: as a fact of disaggregation, which ever renews the evolution of the species, and which retards its equilibrium by multiplying the conditions under which the species may, under the influence of the incident forces of the environment, undergo a more perfect elaboration, the result of which shall be a better adaptation of the organism to its surroundings. Generation is in fact antagonistic to equilibrium, but this antagonism is only temporary, and causes the organic evolution to obey the law of universal rhythm.

[*To be continued.*]

THE CHARACTER OF MODERN KNOWLEDGE.[1]

By J. L. W. THUDICHUM, M. D.

THE science of the present age is distinguishable from the learning of past ages by many important features. By these it has indeed somewhat altered the sense originally attributable to its name, and science has become a word of greater precision, and therefore of a less broad significance than what may be termed mere knowledge. This is so little understood, that when lately a great statesman and orator met some of his constituents in a southeastern suburb of this metropolis, he informed them, among other things, that science was merely another term for knowledge. Even if it had been so originally, and the Latin word *scientia* had been merely the equivalent of the Saxon word knowledge, it would have to be admitted that the relations have changed by one of those conventions which are silent and convenient. We hold that the systemic enunciation of mere knowledge is doctrine; that science is a kind of knowledge, but that not all knowledge is science. Science is that kind of knowledge the correctness and truth of which can be proved by evidence convincing to all healthy understandings. Science is a series of potentialized axioms, which when once mastered are as evident as the simple axioms in mathematics, which are said to be so self-evident as to require no proof. By this definition a very large amount of human knowledge or doctrine is at once excluded from the domain of science. The learning of past ages was mainly imitative, little observant of new phenomena. Those ages had too much work on hand, first in the development of their languages, in which they used imitations countless in number, next in the shape of securing the conditions of social life in the form of communities and states. But even where these may be said to have been secured, e. g., at the height of power of the Roman Empire, science was not developed, and it may be said that this absence of scientific treatment of the common problems of life has been one of the principal causes of the downfall of that, and of many other states. Famines, epidemics, among men and cattle, and wars, are made possible or necessary only by the absence or faulty application of the principles taught by science. Science, by teaching that, and how, these evils are to be avoided, has a field in this generation, of which the past had not even a distant conception. Imitative learning shows itself mainly as art, buildings, sculptures, paintings; all the mass of temples and gods which fill the world's history and imagination are of this kind. There is no science about a Greek or Egyptian temple, simply because there is no value in it; it does not satisfy, to

[1] Introductory remarks to a course of lectures on the "Life and Labors of Prof. Liebig.

our present mode of thinking, one single demand of the understanding. There is no science about our present homes, or how could they get filled with sewer-gas, be devoid of arrangements for ventilation, and have square chimneys. Architecture, so called, is not a science, but an imitative art, beautiful but blundering. Manufactures have, too often, been carried on with great disregard of science, with the result that either empiricism was, for the time, successful enough, or that the manufacture went simply out of existence. It is the same with commerce. These arts have worked by tradition, by prescription, by precedent. They all wait for an infusion of the scientific method, the method of principle based upon natural laws immutable and indestructible. While not often scientific themselves, these branches of human knowledge, administering all the time, for a consideration of gain to be paid by the recipient, to important human wants, have yet indirectly advanced science by either finding and bringing, or by producing some of its materials.

Antiquity, then, possessed no science, except alone the results of meditation, which have been termed metaphysics, and which, if allowed to include ethics and logic, have no doubt attained in the treatment of philosophers a high degree of development. The contemplation of Nature, however, in its inorganic and organized shape, and of the causes determining all motion and development, was not greatly developed. The power of distinction, the mother of all knowledge, was not applied to all things, and consequently they termed a process such as fire an element, and allowed some all-pervading material to exist under the name of the quintessence. Bodies fell to the ground because they possessed weight; but that the falling was a reciprocal action between the earth and the body falling upon it escaped their observation, and was only found by science.

Mere observation is not science, but only the beginning of science. When a person, sitting in the railway-train, beholds the traveling shadow, he makes an observation. He begins a scientific inquiry, when he asks whether the shadow travels as quickly as the train, so as to be in a line falling from the sun past the train or whether the shadow is not a little later. If once the question has arisen, it is immaterial where it is solved, whether upon the railway-train, or the satellites of Jupiter—the question must lead to the idea that light requires time for traveling; exact science determines this time by measuring space. Science began its development with the elucidation of celestial phenomena, and became astronomy, or the doctrine of the laws according to which heavenly bodies move. Copernicus is from this point of view the father, the creator of science. Kepler, Galileo, and Newton, reduced the observations of these phenomena to expressions of regularity which we call laws. The method once found was applied to other branches of knowledge; then arose the physiology of the animal and vegetable world, based upon anatomy as a science.

Harvey made physiology a science, and so on in all branches of knowledge.

Now, let us see what was the method by which these results were obtained. Meditation had of course the inciting share, but furnished no materials. Observation accumulated the materials of which reflection might weave a tissue, the test was experiment. If from a knowledge of conditions a result can be predicted, then there is certainty. Such certainty is science; it consists of observation, meditation, knowledge of conditions, knowledge of their results, and therefore of the connection between results and causes; these being regular, immutable, within the time accessible to our perceptions, and coercing everything under their sway, are called natural laws.

Of science, it is allowed that no part comes out of the human brain alone, not even the ideas of God and Immortality, which Kant claimed as innate ideas, while allowing all others to be the result of observation and reflection. The celebrated joke, that, if an Englishman and a German were asked to produce a camel each, the Teuton would evolve one out of his inner consciousness while the Briton would produce a camel of flesh and bone, is a good satire upon innate ideas. Science did not progress until it rejected all innate ideas or phantasies, and applied itself deeply to its proper methods, to observation, to meditation on the correlation of forces, and to experiment. Work, work, and again work, were the three main features of its success. The search for the philosopher's stone, for the medicine that should make young, healthy, happy, and rich, was also work, enormous in amount and extension, but it was not based upon observation. It left results which science gathered, the main result being that we cannot prolong our lives forward, but we can, as Kopp has beautifully said, prolong them backward indefinitely, and see the changes of enormous spaces of time pass before our admiring eyes and minds.

There are three kinds of history, that of our planetary system in the theory of Laplace, that of our earth in geology, that of living things in the theory of Darwin. No serious person doubts now that the teachings of geology deserve the title of an exact science, and that compared to its coercing character upon the mind of man the convictions derived from written history are feeble in the extreme, and all contradictory writings, however old, mere nullities. The youngest of the sciences or branch of science is chemistry, founded by Lavoisier and Dalton; developed by thousands of clear heads and nimble hands, it has in half a century become a recognized power in the affairs of man. It has materially improved his estate, and enlarged his mind to conceptions of an elevating nature; it has become a ready test of his reasoning and working power. It has become the handmaid of almost all the elder sisters of astronomy, teaching the composition of distant stars; of geology, teaching the composition and changes of strata and minerals; of physiology, vegetable and animal, teaching about food,

nutrition, growth, changes, death, and decay; of the healing art, teaching the nature of evils in the shape of disease, and the means of curing or mitigating them. This science, too, was developed by work, work, work—physical and mental; its ways were often rugged; its endeavors misapprehended, opposed, suppressed. And the great men whose names are inscribed upon the roll of its principal promotors will be considered by posterity as benefactors akin to Hercules, removing evils, establishing the good and true. If we cannot now inscribe their names and likenesses among the stars, and transfer them to an Olympian abode, yet we can honor them by admiring their works and lessons, by sharing and continuing their work, by, as it were, living their lives with them over again, and thus prolong their memory forward while we prolong our own in the inverse direction. We ought to honor them out of gratitude no less than out of the desire to benefit continuously man's estate. Such feelings have been instrumental in the cases of those who described the greatness of your Davy, of your Faraday. Such feelings shall now be the guiding principle in the consideration of the life, works, and philosophy of Justus Liebig. But I must beg you to understand that I shall proceed by a severe process, that of analysis, for nothing less than the results of analysis of work done can establish as proved what many feel as a sentiment. You will understand both the censure and the acclamation of what we will call the world; you will see the necessity for a reform in the philosophy of many of us; you will see how the life and labor of one man have produced vast applications and industries, improved or created a large commerce, and enhanced or engendered art; how they have soothed the pain and anguish of hundreds of thousands under the most severe trials of human organization, and how they have left a growing harvest in the hearts and minds of men all over the world.

THE RELATIONS OF SEX TO CRIME.[1]

By ELY VAN DE WARKER, M. D.

SEXUAL cerebration may here and there be seen coming to the surface, amid the complex array of circumstance and causes which affects woman's criminal career. If I am correct in the use of the term, and it surely has the merit of expressing the idea designed to be conveyed by it, we may perceive two forms of sexual mental action, one normal and the other abnormal. Its action in the normal phase may be seen in favoring or obstructing her career in crime, in relation to particular offenses; while its abnormal manifestations may be perceived in certain crimes, existing as a direct outcome of its pres-

[1] Argument continued from January MONTHLY.

ence. It must be observed that sexual cerebration in its relation to crime is not confined in its operation to the female sex. Its influence on men may be observed in many of the crimes in which they exceed their usual ratio of excess over women. Man's tendency to belligerency evidently accounts in a measure for his great excess in the crimes of murder and assassination. Attempts have been made to explain this by the frequency of drunkenness, and the street brawls which it leads to among men; but, when we take into consideration the fact that the ratio of the sexes for drunkenness in England is, 1 woman to 1.49 men (Quetelet), we perceive that this cause can but act to a very limited extent. The sexual mental tendency of man to the wager of battle, his physical strength, the almost unlimited opportunities afforded by the greater range of his activities, enable man to exceed his usual ratio of excess over woman in these two crimes. Crimes against property, such as robbery from the person or highway robbery, also offer evidence of the innate cerebral traits of the male. In this offense man stands almost alone. It requires for its successful perpetration bravery and daring. These are qualities belonging peculiarly to men. In view of the intensity of feeling which attends all discussion of matters in which women are concerned, either socially or sexually, I think it better to qualify the last sentence, by calling the attention of the reader to the very proper distinction between moral and physical courage. The first exists as the result of intellectual qualities, education, and moral training; the last is purely a phase of sexual cerebration. Some of the most beautiful examples of moral courage are constantly offered by women. It is the possession of physical courage which is requisite to the commission of the crime alluded to, and not its higher prototype, moral courage. This form of sexual cerebration in the male is the coefficient of belligerency in the perpetration of many crimes, and united to physical strength is, aside from opportunity, capable of explaining many of the circumstances attending man's excess over woman as a criminal.

The action of sexual cerebration in its normal expression, as affecting the relation of men to crime, has been traced far enough to demonstrate its important influence. Its operation in men is more easily detected than in women. Man's career as a criminal is attended by fewer complicating conditions. By the broader field of his activities, he is directly exposed to criminal influences, while woman is hedged in by the circumstances of her position. She lives in an atmosphere of restraining influences, each one of which tends to obscure the effect of the subtile yet potent sexual mental traits which characterize her as a woman. The extent to which woman conforms to a common mental type may be more surely measured by contrasting her as a criminal with man in his relation to crime, than by studying her alone in her usual social relations. Crime reveals to us some of the primeval tendencies of society. By crime, notwithstanding all the varied results

of civilization—a scion, as it were, grafted upon the parent trunk—humanity is wedded to its original savagism. Certain sociologists of the religious school teach that crime is the outcome of civilization, that it increases or decreases in proportion to the extent and quality of religious teaching; but an examination of the criminal returns of various peoples shows that crime exists at nearly a fixed ratio without regard to religion, be it what it may. Some forms of crime are, beyond doubt, increased by the artificial needs of society in its civilized form, infanticide and abortion, for example; yet even these crimes prevail universally among the most primitive races. Civilization has not modified the crime, it has simply changed the motive. With the tendency to crime existing at the ultimate fibres of man's psychical life, the expression of sexual cerebration in the criminal conduct of women assumes a naturalism called forth by no other social relation. As I have separately examined the matter of sexual mental types in a former article, all that is necessary here is, to apply the conclusions there reached to woman's tendency to crime.

The crime of poisoning, with its remarkable ratio, has been used a few pages back to illustrate the influence of the physical factor. It was called the weapon of weakness. This weakness is twofold, physical and mental. Women possess moral courage, but not physical. Timidity, a shrinking from bodily danger, a fear of combat, each an analogue of the other, appear as mental traits in the average woman. Here is an offense gauged to woman's mental and physical aptitudes. By means of poison, a fatal blow may be given by the weakest arm without the fear of combat, or of physical hurt. To a mind with criminal tendencies, hampered by the reflex consciousness of weakness, the security, the secrecy, are charming. The result is that, as a poisoner, woman nearly equals man. This equality among the lists of crime nowhere else appears except in offenses against the currency, a crime also remarkable for its secrecy, and freedom from personal encounter during its perpetration. If a further extension of the statistics of crime against the currency confirms the ratio of the sexes deducible from Mr. Neison's tables, it will amount to nearly a demonstration of the fact here shadowed forth, that woman tends to equal man as a criminal in those crimes which require neither physical courage nor strength as conditions of their perpetration. The crime of vagrancy is the only exception that offers itself, and which loses its force as an exception under the law of criminal analogies. From the crime of poisoning, the climax of the criminal tendency, downward through the lighter shades of offense, this phase of sexual cerebration may be detected. If it were possible to give to woman the physical strength of man with this mental trait existing in its present force as a sexual characteristic, I doubt if it would alter essentially the known ratio of the sexes for murder and the wounding of strangers—9 to 100. I venture this prediction merely for the purpose of illustrating the potency of this

mental factor touching woman's criminal relations. In robbery from the person, although the enormous disproportion in the ratio is in a measure explained by differences in physical strength, yet there remains much of this excess of men to be explained by other means. That which remains to be explained by means other than that of sexual differences of physical strength may be stated in this way: The ratio of the strength of the two sexes being fixed at 16 to 26, and the ratio for crimes in general against property being 26 to 100, we nevertheless find that for the crime mentioned the ratio is reduced to 8 in 100. Here is a difference in ratio between two classes of the same division of crime of 18 to 100. Evidently, it is too largely in excess of the ratio of strength of the sexes, to be entirely accounted for by that alone. This phase of sexual cerebration, together with woman's social conditions, is competent to explain the differences remaining unaccounted for. The crime of self-murder also brings out quite distinctly the action of this mental trait in women. An examination of the methods of self-destruction reveals sexual peculiarities. Men prefer cutting instruments and fire-arms, while women select poison, and hanging and drowning (Quetelet). A collection of nearly five thousand cases of suicide, by M. Brierre de Boismont,[1] reveals the fact that hanging occurs more frequently among women than men, by a large percentage. It will be noticed that women select those modes of suicidal death which take the matter out of their own hands. They offer a surety for their fainting spirits by closing the avenue of escape behind them. However painful may be the death they seek, after the fatal draught, the fall, or the plunge, all voluntary power of escape is beyond their reach. Is it not from the consciousness that lack of physical courage, or timidity, would involuntarily cause them to escape from the pangs of death, that they select a method of destruction which after the painless first step renders such a return impossible? Cortes, who knew the temper of his men, burned his ships upon the shore; and in the same way women assure themselves of the impossibility of return ere they attempt suicide.

The influence of the excess of the emotional life in women over men, upon their criminal career, is not so marked as that of the psychical traits just considered. I stated in a former chapter that there was evidence which rendered it probable that those emotions or passions which serve as the incentives to crime approached in intensity the same mental conditions in man. In that portion of these contributions devoted to "Sexual Cerebration," emphasis was given to the fact that the emotional life of woman exceeded that of man. At this point in the study we can give this practical significance. The emotions offer vulnerable places in woman's moral armor. These mental sexual attributes which give such grace and beauty to woman's character cannot exist except at the expense of rigidity and sternness of

[1] "Recherches Medico-Légale sur Suicide," Paris, 1860.

mind. Through all Nature may be found analogies which give probability to this. Nature, in her forms of fixity and power, is massive and rugged in her outlines; it is only in her phases of changing, transient life, that she assumes lines of beauty, delicacy of shape, and clothes her proportions in the subtile harmonies of color. I do not deny woman firmness of character; but surely, whatever firmness she possesses, it is not by reason of her emotions that it exists. Nor do I wish to be understood as saying that any excess of emotion woman may possess over man is necessarily the cause of inherent weakness of character; but, the idea I intend to convey is, that excessive development of the emotions affords a way of approach to the firmer characteristics of her mind of those exciting causes of crime, which, without these avenues, must act with less force as criminal factors. The evidence of this lies in the tendency of woman to exceed in a marked manner her ratio to crimes in general against the person when exposed to the action of causes which act more or less directly upon her emotional life. Women perpetrate crimes, involving human life, more frequently within the circle of their domestic relations than men (Quetelet). In view of this fact, let us inquire as to the probable motives which cause women to exceed men in crimes against persons within this restricted area. If we were to explain it as the result simply of the great opportunity women have of perpetrating crime in the family, it leads to the conclusion that women's criminal tendencies exceed those of men under favorable opportunities, and which men in the same relation possess to an equal extent. This we know is a wrong conclusion; therefore, while we must allow the great facilities afforded to women a certain value as a factor in this excess, yet it is not adequate to explain the fact. It is in the family that woman finds a field for the free action of her emotional life. It is as an outcome from these emotions that the family exists; it is through these emotions that the most deadly wounds may be inflicted upon her morality and self-respect. In the majority of cases, if through her error, or that of others, the family is a failure, the woman of the family is a failure also. In this can be found the strongest argument for encouraging woman to become expert in some form of labor, so as to enlarge the field of her self-dependence, that she may be able to secure safety for herself in the trying hour of domestic misfortune. While the family is called into existence by reason of the most potent sexual mental traits, and finds its strength and permanency in a temperate use and even balance of the emotions, it may become the source of the most active criminal impulses. Conjugal incontinence, jealousy, a misplaced love, may create the most deadly strife in the family circle. Especially is this true if the criminal tendency exists latent, as an inherited taint, in the members of the family, and ready to be kindled into life by emotions which, in others, free from inherited vice, would not pass beyond the control of the moral faculties. Man, whose activities are

less confined within the area of domestic life, is more able than woman to resist the action of the emotions. Another cause, which comparatively releases man from the criminal tendencies which grow out of a violated emotional life, is the weaker hold these emotions have upon his conscious life. These are my reasons for concluding that this excess over men, as a criminal against persons, within these limits, is the result of the more active development of the emotions in women.

Considering that, in the purely sexual relations of men and women, the male is the active and the female the passive one, the ratio between the sexes for the crime of adultery offers additional confirmation of the foregoing. For this purpose I shall select the statistics of M. de Marsangy, than whom none can be selected more favorably disposed to women. This author places the ratio for men at 528, and women at 472 to 1,000.[1] As these were cases which came under the notice of the public prosecutor, it is reasonable to suppose that the circumstances attending them were in both sexes of a flagrant character, so that possibly the usual attitude of the sexes toward each other in this offense was reversed. These ratios render the assumption safe that it is in crimes which grow out of the acute and excessive emotional life of women that they tend to equal men as criminals. If it were any tendency to crime, growing out of sexual mental traits possessed more equally in common than the emotions, which causes the tendency to equality above referred to, it would be reasonable to expect to find the sexes occasionally approaching a common ratio in crimes against property, and which could be traced to the same mental traits. But a careful survey of the field shows this not to be so. Woman's delicacy and keenness of emotional life, when their undue exercise or unbalanced proportions seek expression in the criminal act, lead to crimes against persons, not against property. Even incendiarism, so commonly practised by men from motives of revenge, is but seldom attempted by women. The enmities of women are never general. They are roused by particular persons and special acts; hence their revenge takes an individual direction, not against the property, but against the person of the enemy. The wounding of parents, and parricide, exceeding by so large a ratio all other acts of violence against the person, I believe can be explained in no other way. Admitting, as I have already done, that the great opportunity afforded of making attempts upon the persons of parents has some value as a factor, yet we must bear in mind that, from the nature of their domestic life, women have opportunities equally as great of inflicting injury upon others. It follows that opportunity as it affects parents must be given exceptional value, in order to account for their being the objects of criminal attempts on the part of daughters, over that of other persons holding a domestic relation. The ratio of crimes against parents also makes it very probable tnat the purely sexual emotions are

[1] *Loc. cit.*, table, p. 147.

not particularly important as factors in the grave class of crime now under consideration. So far as it relates to parents, these emotions may be excluded. Other emotions must in parricide be called into action. But, in poisoning and crimes affecting others beyond parental relation, I believe the purely sexual emotion is the main ingredient in the motive. M. Quetelet states that adultery, domestic quarrels, and jealousy, cause nearly an equal number of poisoning in both sexes; but in murder the number of women by the husbands exceeds the number of husbands by the wives. In poisoning, with the ratio of 91 to 100, for all motives and against unspecified persons, we perceive that when the crime is brought within the domestic circle and against persons bearing a very close relation to women and narrowed down to these motives, all differences between the sexes disappear. This is brought out in order to make clear the fact that women are not worse than men, but that under conditions favorable to their more restricted sphere of activities, and from motives operating in the direction of their peculiar psychical traits, they will equal men in the perpetration of those crimes suited to their strength. Crime, as it relates to men and is perpetrated by them, conforms in an equal manner to their physical and mental characteristics, and exists in a ratio with the sphere of their activities. While a difference of morality may exist between the sexes, it is not equal to explain the constantly varying ratios of the sexes to crime. Whatever the differences of morality may be, it is not sufficient to create any difference in the tendency to crime, when the crime conforms to the conditions just stated. The abnormal action of mental sexual traits is more often met with among women than among men. M. Prosper Despine assigns great importance to the moral perversions which accompany the hysterical tendency in women, and regards it as one of the marked characteristics of sex in crime. Hysteria in its myriad forms, when it disturbs cerebral function, appears to be a perversion of the emotional faculties. An offense committed during an attack of hysterical insanity is not of course a crime, as I am here studying it; but it is a grave question, to what extent may the criminal habit grow out of the perversion of morals which may attend the hysterical state of mind? In the course of two years' acquaintance with criminal female convicts, I became impressed with the fact that nearly every one of them gave evidence of possessing hysterical tendencies. In connection with this tendency, another significant fact was observed—the power to control the expression of the feelings and emotions was much less in them than in the average woman. Women who are liable to attacks of hysterical perversion of the emotions are usually under the direct influence of the diseased action but a short time, so that the possibility of criminal attempts at such times is comparatively limited. It is not therefore the presence of an actual attack of hysteria which promotes the tendency to crime; but the impaired control over the desires and emotions which coexists with the hysteri-

cal temperament may lead to this. Which is the cause, and which the effect, it is difficult to assert. From the prevalence of hysteria among prostitutes—a class who habitually permit the desires and emotions to pass beyond healthy control of the will—I infer that this precedes the actual attack of the disease. In some cases, however, hysteria results from organic derangement, usually of the sexual organs, and then the lack of emotional control may be a secondary instead of primary condition. The criminal resultant, in my experience, is confined to crimes against property, false accusation, and infanticide. It rarely leads to the more serious crimes against persons, for the reason that the wrongs of the hysterical are fancied rather than real, which disappear with the usually prompt return of judgment.

The following history of a false accusation reveals the defective control over the feelings and the perversion of the sexual emotions which coexist with the hysterical tendency: Esther was a young convict, about twenty years old, committed for a term of years to the Onondaga penitentiary for a second offense of stealing. She married very young, and lived with her husband but a short time. Her occupation was that of a domestic, and when not employed always went to her home, which was respectable. She gave considerable trouble in the shops, by her moody and disobedient ways, and would often refuse her food, and was then taciturn and desponding. Her cell was situated near the centre of the block, on the second gallery, and was lined with pictures cut from the illustrated newspapers. The collection was remarkable from being made up of the pictures of men and women, some of them neatly framed with straws. A cross, made of the thin shavings of wood used to light cigars with, was prominent among the decorations. She gave me considerable trouble with her great variety of fancied ailments, and I believe the girl actually believed in her diseases. The keepers believed her to be a "beat," a most unfortunate reputation for one to earn while under the discipline of a penitentiary. Esther startled the prison officials one morning, by charging the night-watch—a most estimable young man—with visiting her cell at night. From the method of locking the cells, this appeared to the officers nearly an impossible thing for the watchman to do. A careful examination of the inmates of the adjoining cells failed to elicit any confirming evidence; yet Esther persisted in her charge, to the great distress of the young man. As Leander nightly buffeted with the waves of the Hellespont for the love of Hero, it was thought possible that love might contend not less successfully with patent locks and prison-bars. It was therefore considered the safest course to remove the young man. When Esther was informed of the effect of her charge, she at once retracted. Now, the motive of this accusation constitutes the essence of the story. Esther loved the night-watch. She had for months fed her passion on the sight of the young man. The class of

people to whom this woman belonged do not possess imaginations sufficiently acute to invest love with any charm. Their relation with an object of love is emotional; their only gratification is possession. As possession was impossible, there was yet a way to establish a link between herself and wished-for lover. She brought a false charge against a man who had never spoken a word to her in his life. She took pride in the fact that his name was associated with hers in a manner most congenial to her emotions. It was the nearest approach to possession possible. This girl was very properly placed upon bread and water for her offense; but I am quite confident that such a false accusation, except for purposes of revenge, is only possible in a woman of hysterical tendencies, and in whom the emotions have passed beyond the inhibitory power of the moral sense. A false accusation of this nature is not a very rare one for women to make, and it is usually accompanied by two noteworthy circumstances—the woman is generally very young, and the man in some way nearly unattainable by the accuser.

To the liability of insanity to accompany the hereditary transmission of crime, I have already made sufficient reference; but the class described above are not insane, they simply lack the normal equipoise between the different faculties of mind. As to how far this may affect the relations of women to the different classes of crime we have no means of forming an opinion. As it is a mental characteristic more frequently observed in women than men, it is reasonable to suppose that it has some influence. Its effect upon the votaries of the social evil is, however, very great, and careful study will be made of it in the chapter devoted to woman's crime against her sex.

Particular stress has been laid by other authors upon the fact that the great excess of men over women in certain crimes against the person, as murder and assassination, was the result of intoxication and brawling to which men are addicted. If this is one of the factors of such excess, it will be interesting to know it. If this is any explanation, it follows that one sex must so greatly exceed the other in the matter of intoxication and disorderly conduct, as it is termed by the police courts, as not only to include the ratio between the sexes for crimes mentioned, but also to include the chances of no such result following, as but a small percentage of debauches and brawls results in either murder or assassination. As it is in great cities that men addicted to disorderly conduct are mostly to be found, and as there also they are more liable to terminate in crimes against the person, I shall select statistics from cities touching upon this matter, bearing in mind, however, that a perfect contrast between the sexes cannot be secured, as the offenses under analysis include drunkenness and fighting in the male, and both those, with the addition of prostitution, in the female. The ratios are based upon the statistics furnished by the report of the Commissioners of Public Charities and Correction. For

the period covered by the reports, 90 per centum of those arrested for disorderly conduct and intoxication were women.[1] It becomes evident at once that the excess of men over women, in crimes against the person, cannot to any extent be accounted for by the proneness of men to intoxication and disorderly conduct, and which we perceive does not so greatly exceed that of women. Instead of searching among accidental qualities for the causes of this difference, rather ought we to examine the mental and physical qualities which exist inherently in man. From the same source we may gain an idea which bears in another direction upon this matter. The ratio of drunkenness and disorderly conduct to total crime, for the sexes separately, furnishes nearly positive proof that it has but a restricted influence upon the tendency to crime in general. Thus, these offenses furnish 41 per centum of the total crime committed by men; while, of the total crime committed by women, 80 per centum is of the same nature. While the number of drunk and disorderly among men is larger by a small excess than the number of women so addicted, yet women considered by themselves exhibit twice the tendency to these offenses that men do. Here, the sex which affords the least measure of total crime gives the largest ratio, relatively to her own sex, of those offenses which are so generally supposed to underlie the criminal tendency. The explanation I would offer of this rather unexpected result is, that intoxication and disorderly conduct are offenses closely allied to vagrancy and its analogue, prostitution; that this class represents the effete among men and women who gravitate into vice from total lack of vitality and energy to keep themselves up to the level of the average. The active criminal requires mental and physical energy in order to pursue his course. Any of the conditions of life which depress the physical powers and deplete mental energy tend to remove those with criminal tendencies from the order of active criminals, and place them among those addicted to the minor degrees of crime. While habitual intoxication and disorderly conduct lead to the lighter offenses against property, the more serious crimes against property and persons are comparatively unaffected by these causes, either among men or women.

CAROLINE LUCRETIA HERSCHEL.

By ELIZA A. YOUMANS.

MOST people in this country have heard of Miss Caroline Herschel the astronomer. Without knowing much about her, she has been vaguely regarded by the public as a profound scientific genius, the strong-minded peer and coadjutor of her brother, the

[1] "Reports of the Prison Association of New York," Tables "C," "D," "E," "F," 1867, and Tables "C," "D," "E," "F," "G," "H," 1871 and 1873.

illustrious Sir William Herschel. It is supposed that she rose above the narrow sphere of woman's usual domestic life, and spent her time in studying the universe and making astronomical discoveries. She has been often cited, in the recent discussions of the woman question, as an illustration of the intellectual equality of the sexes and as demonstrating to the world what woman is capable of doing in science when she gets a fair opportunity.

Miss Herschel's memoirs have just appeared, made up mostly from her diary and correspondence, edited by Mrs. John Herschel. In this interesting volume we get a view of her real character, and discover that the notions generally accepted are widely mistaken. We learn from her diary and letters that, while she was a thrifty and interested housekeeper, she had neither the taste, the ambition, nor the mental qualities, that would have insured distinction in an independent intellectual career. It is seen that she became an astronomer by accident, as it were, and through the strength of her affection rather than of her intellect. When she found that her brother had resolved to take her as his assistant in his astronomic labors, it made her miserable for a time; and he chose her instead of either of his brothers, not because of her brilliant mind, but on account of her persevering devotion to his interests and her dexterity and readiness in doing an assistant's work.

The lesson of this book is very important to ambitious girls who despise domestic concerns, and long for an "intellectual" career. Her science, as such, gave Miss Herschel no great enjoyment; her happiness came from her womanly devotion to her brother's ambitious work; and the book will be found painfully interesting as it discloses the sufering she also experienced as the penalty of this unselfish devotion.

Miss Herschel lived to the great age of ninety-seven years and ten months, and retained her faculties bright to the last. We give a portrait, taken from the biography, which represents her at the age of ninety-two. In the following sketch we shall let her speak for herself, as far as practicable, as nothing can exceed the graphic simplicity of her diary. But, as she was a German, and did not begin to study English till she went to England, at the age of twenty-two, there are defects in her writing, for which the reader will make due allowance.

Caroline Lucretia Herschel was the eighth of a family of ten children, four of whom died in childhood. Her father was band-master in the regiment of Guards at Hanover, and all his children had musical genius. He took great pains to cultivate his sons in music, and sent them to the garrison school for their routine education. As they grew up they all became musicians and joined the regiment band. At Dettingen, in 1743, the father was wounded and left all night in a wet furrow, and he had ever after an impaired constitution and an asthmatical affection. This event cast a shadow upon the family, and when Caroline was born, in 1750, in the gloomy period of the Seven Years' War, the mother's temper seems to have been already warped by trouble.

Her turn of mind was practical and plodding, while the father was intellectual and aspiring. It is abundantly evident that Caroline had a bitter and desolate childhood. Expressions of affection or regard from her relatives were very rare in her experience, while her own sympathies had a most precocious development. It is said that when only three years old she was deeply concerned about family troubles.

Her only sister, the oldest child of the family, was married to a musician named Griesbach. Jacob, the eldest brother, was organist at the garrison church; and William, four years younger, was already remarkable for his splendid talents, apart from music. In the following passage from her diary we have a picture of the family at this time:

"My brothers were often introduced as solo performers and assistants in the orchestra of the court, and I remember that I was frequently prevented from going to sleep by the lively criticism on music on coming from a concert, or conversations on philosophical subjects, which lasted frequently till morning, in which my father was a lively partaker and assistant of my brother William by contriving self-made instruments. . . . Often I would keep myself awake that I might listen to their animating remarks, for it made *me so happy to see them so happy*. But generally their conversation would branch out on philosophical subjects, when my brother William and my father often argued with such warmth that my mother's interference became necessary, when the names of Leibnitz, Newton, and Euler, sounded rather too loud for the repose of her little ones, who ought to be in school by seven in the morning. But it seems that on the brothers retiring to their own room, where they shared the same bed, my brother William had still a great deal to say; and frequently it happened that, when he stopped for an assent or reply, he found his hearer was gone to sleep; and I suppose it was not till then he bethought himself to do the same.

"The recollection of these happy scenes confirms me in the belief that, had my brother William not then been interrupted in his philosophical pursuits, we should have had much earlier proofs of his inventive genius. My father was a great admirer of astronomy, and had some knowledge of that science; for I remember his taking me into the street to make me acquainted with several of the most beautiful constellations, after we had been gazing at a comet which was then visible. And I well remember with what delight he used to assist my brother William in his various contrivances in the pursuit of his philosophical studies, among which was a neatly-turned four-inch globe, upon which the equator and the ecliptic were engraved by my brother."

But this little household was soon broken up, the regiment of Guards being ordered to England in 1755. The parting scenes are thus described:

"In our room all was mute, but in hurried action; my dear father was thin and pale, and my brother William almost equally so, for he was of a delicate constitution, and growing fast. Of my brother Jacob, I only remember his starting difficulties at every thing that was done for him, as my father was busy to see that they were equipped with the necessaries for a march. The whole town was in motion, with drums beating to march; the troops hallooed and roared in the streets, the drums beat louder. Griesbach came to join my father and brothers, and in a moment they were all gone. My sister fled to her own

room. Alexander," [her third brother] "went with many others to follow their relatives for some miles, to take a last look. I found myself now with my mother, alone in a room all in confusion, in one corner of which my little brother Dietrich lay in his cradle; my tears flowed, like my mother's, but neither of us could speak. I snatched a large handkerchief of my father's from a chair, and took a stool to place it at my mother's feet, on which I sat down, and put into her hands one corner of the handkerchief, reserving the opposite one for myself. This little action actually drew a momentary smile into her face."

They were gone a year, and of this period of separation she gives no recollections; but in her account of their welcome home we see how affectionate she was and how neglected she felt, and the kind treatment of her brother William could not fail to make a deep impression upon her susceptible nature:

"My mother, being very busy in preparing dinner, had suffered me to go all alone to the parade to meet my father, but I could not find him anywhere, nor anybody whom I knew; so at last, when nearly frozen to death, I came home and found them all at table. My dear brother William threw down his knife and fork and ran to welcome, and crouched down to me, which made me forget all my grievances. The rest were so happy at seeing one another again that my absence had never been perceived."

In 1757 it became apparent that William had not the strength to stay in the Guards in war time, and his parents, with no small difficulty, sent him away to England.

When very young, Caroline went to the garrison school till three in the afternoon, and then to another school to be taught knitting. From the time she was six or seven years old, she says:

"I was fully employed in providing my brothers with stockings, and remember that the first pair for Alexander touched the floor when I stood upright, finishing the front. Besides this my pen was frequently in requisition for writing, not only my mother's letters to my father, but many a poor soldier's wife in our neighborhood to her husband in camp."

From 1757 till 1760 there is another gap in the record, several pages having been torn from her manuscript belonging to this period. In 1760 her father came home for good, broken in health and worn out with hardships, and we are again furnished with some details of the family history. He devoted himself for the rest of his life to the musical education of his children, and gave lessons besides to the numerous pupils who sought his instruction. Next to her brother William, her father was the object of her dearest love. She was her mother's companion and, assistant, and, as the income was straitened, they together did all the housework. The mother was a diligent spinner, and kept the family well stocked with household linen. Her sister had not a patient temper, and was sometimes left, with her goods and chattels, to be taken care of by her mother. As to Jacob, who was often at home, and who developed into a dandy while in England, she speaks of him as follows:

"When he came to dine with us it generally happened that before he departed his mother was as much out of humor with him as he was at the beefsteaks being hard, and because I did not know how to clean knives and forks with brick-dust." And again: "When he honored the humble table with his presence, poor I got many a whipping for being awkward at supplying the place of footman or waiter."

It is said that his love of luxury was shown in the specimens of English goods and English tailoring he brought back with him from England, while all that William brought back was a copy of Locke "On the Human Understanding," which took all his private means.

When her father came home to stay he helped her some, and yet, poor man, he did it under difficulties. The parents had never agreed upon the subject of her education. She says:

"My father wished to give me something like a polished education, but my mother was particularly determined that it should be a rough but at the same time a useful one; and nothing further she thought was necessary but to send me two or three months to a seamstress to be taught to make household linen. Having added this accomplishment to my former ingenuities, I never afterward could find leisure for thinking of any thing but to contrive and make for the family, in all imaginable forms, whatever was wanting; and thus I learned to make bags and sword-knots long before I knew how to make caps and furbelows. . . . My mother would not consent to my being taught French, and my brother Dietrich was even denied a dancing-master, because she would not permit my learning along with him, though the entrance had been paid for us both; so all my father could do for me was to indulge me (and please himself) sometimes with a short lesson on the violin, when my mother was either in good-humor or out of the way. Though I have often felt myself exceedingly at a loss for the want of those few accomplishments of which I was thus, by an erroneous though well-meant opinion of my mother, deprived, I could not help thinking but that she had cause for wishing me not to know more than was necessary for being useful in the family; for it was her certain belief that my brother William would have returned to his country, and my eldest brother not have looked so high, if they had had a little less learning. . . . But sometimes I found it scarcely possible to get through with the work required, and felt very unhappy that no time at all was left for improving myself in music or fancy-work, in which I had an opportunity of receiving some instruction from an ingenious young woman whose parents lived in the same house with us. But the time wanted for spending a few hours together could only be obtained by our meeting at daybreak, because by the time of the family's rising, at seven, I was obliged to be at my daily business. Though I had neither time nor means for producing any thing immediately, either for show or use, I was content with keeping samples of all possible patterns in needlework, beads, bugles, horsehair, etc., for I could not help feeling troubled sometimes about my future destiny; yet I could not bear the idea of being turned into an abigail or housemaid, and thought that with the above and such like acquirements, and with a little notion of music, I might obtain a place as governess in some family where the want of a knowledge of French would be no objection."

As year by year passed by, William's attachment to England grew stronger. But the poor father, who was failing in strength, became

more and more eager for his return, and on the 2d of April, 1764, to the great joy of the family, he made his appearance. The visit was brief, and gave no hope that he would settle in Hanover. In describing it, Caroline is spoken of as "the poor little unnoticed girl," and the event as standing in her memory "fraught with anguish too deep for words." She was disappointed in her hope of enjoying this visit of her brother, for it came at the time of her confirmation. She says:

"With my constant attendance at church and school, besides the time I was employed in doing the drudgery of the scullery, it was but seldom I could make one of the group when the family were assembled together."

The Sunday fixed for his departure was the very day on which she was to receive her first communion:

"The church was crowded and the door open. The Hamburger post-wagon passed at eleven, bearing away my dear brother, from whom I had been obliged to part at eight o'clock. It was within a dozen yards from the open door; the postilion giving a smettering blast on his horn. Its effect on my shattered nerves I will not attempt to describe, nor what I felt for days and weeks after. I wish it were possible to say what I wish to say, without feeling anew that feverish wretchedness which accompanied my walk in the afternoon with some of my school-companions, in my black-silk dress and bouquet of artificial flowers, the same which had served my sister on her bridal day. I could think of nothing but that on my return I should find nobody but my disconsolate father and mother, for Alexander's engagements allowed him to be with us only at certain hours, and Jacob was seldom at home except to dress and take his meals."

The last years of her father's life are thus described:

"Changes of abode, not always for the better; anxieties, on account of Alexander's prospects, and Jacob's vagaries; disappointment at seeing his daughter grow up without the education he had hoped to give her—were the circumstances under which the worn-out sufferer struggled through the last three years of his life, copying music at every spare moment, assisting at a concert only a few weeks before his death, and giving lessons until he was obliged to keep wholly to his bed. He was released from his sufferings at the comparatively early age of sixty-one, on the 22d of March, 1767, leaving to his children little more than the heritage of his good example, unblemished character, and those musical talents which he had so carefully educated, and by which he probably hoped the more gifted of his sons would attain to eminence."

Caroline was now seventeen, with only the barest rudiments of education, and for the next two years the time passed uneventfully in household occupations; but at the age of twenty a new turn was suddenly given to her thoughts by the arrival of letters from William, proposing that she should join him at Bath, in England.

"To make trial if by his instruction I might not become a useful singer for his winter concerts and oratorios, he advised my brother Jacob to give me some lessons by way of beginning; but that, if after a trial of two years we should not find it answer our expectation, he would bring me back again. This at first seemed agreeable to all parties, but, by the time I had set my heart upon it, Jacob began to turn the whole scheme into ridicule, and, of course, he never heard the sound of my voice except in speaking, and yet I was left in the harassing uncer

tainty whether I was to go or not. I resolved at last to prepare as far as lay in my power for both cases by taking every chance, when all were from home, to imitate, with a gag between my teeth, the solo part of concertos, *shake and all*, such as I had heard them play on the violin; and I thus gained a tolerable execution before I learned to sing. I next began to knit ruffles, etc. For my mother and Brother Dietrich, I knitted as many stockings as would last two years at least."

During all this time she was sorely troubled about her duty in the matter of leaving her mother, and she thus speaks of her feelings:

"In this manner (making prospective clothes for them) I tried to still the compunction I felt at leaving relatives who, I feared, would lose some of their comforts by my desertion, and nothing but the belief of returning to them full of knowledge and accomplishments could have supported me in the parting moment. . . . My brother William, at last, quite unexpectedly arrived. . . . His stay at Hanover could at the utmost not be prolonged above a fortnight. . . . My mother had consented to my going with him, and the anguish at my leaving her was somewhat alleviated by my brother settling a small annuity on her, by which she would be enabled to keep an attendant to supply my place. . . . But I will not attempt to describe my feelings when the parting moment arrived and I left my dear mother and most dear Dietrich, on Sunday, August 16, 1772."

After a dismal journey of six days and nights, in an open post-wagon through Holland, and a stormy passage across the Channel, she arrived in England on the 26th, bareheaded, her bonnet having been blown into a canal from the post-wagon, and the first part of her "Recollections" ends with an account of her experiences in London at this time.

Before resuming Miss Herschel's diary it is needful to explain that, at the time she came to live with him, William Herschel was an eminent teacher of music at Bath, an organist with a choir under his management, a composer of anthems, chants, etc., and director of public concerts. But he followed music solely for the income it afforded; every leisure moment he could get by night or by day being devoted to the study of astronomy. He was known among his music-pupils as an astronomer, and some of them had lessons from him in this science as well as in music. He early applied his inventive talents to the improvement of telescopes. He began by getting from one of the shops a two-and-a-half-foot Gregorian telescope which served for viewing the heavens and for studying the construction of the instrument. Then he began to make instruments himself, which he went on improving and enlarging till at last the mirror for his great forty-foot telescope resulted. Such were the occupations of the brother whom Miss Herschel came to England to help. What she did and with what success is told in the following extracts from her "Recollections:"

"On the afternoon of August 28, 1772, I arrived with my brother at his house at Bath, No. 7 New King Street. I knew no more English than the few words which I had on our journey learned to repeat like a parrot, and it may be easily supposed that it would require some time before I could feel comfortable among strangers. But, as the season for the arrival of visitors to the baths

does not begin till October, my brother had leisure to try my capacity for becoming a useful singer for his concerts and oratorios, and, being very well satisfied with my voice, I had two or three lessons every day, and the hours which were not spent at the harpsichord were employed in putting me in the way of managing the family. . . . On the second morning, on meeting my brother at breakfast, he began immediately to give me a lesson in English and arithmetic, and showed me the way of booking and keeping accounts of cash received and laid out. . . .

"My brother Alexander, who had been some time in England, boarded and lodged with his elder brother, and with myself occupied the attic. The first floor, which was furnished in the newest and most handsome style, my brother kept for himself. The front-room, containing the harpsichord, was always in order to receive his musical friends and scholars at little private concerts or rehearsals. . . . Sundays I received a sum for the weekly expenses, of which my housekeeping book (written in English) showed the amount laid out, and my purse the remaining cash. One of the principal things required was to market, and about six weeks after coming to England I was sent alone among fishwomen, butchers, basket-women, etc., and I brought home whatever in my fright I could pick up. . . . My brother Alexander used to watch me at a distance, unknown to me, till he saw me safe on my way home. I knew too little of English to derive any consolation from the society of those who were about me, so that, dinner-time excepted, I was entirely left to myself."

Of the progress of her musical education, we are told that she was much hindered by being continually called upon to assist in the manufacture of telescopes:

"It soon appeared that my brother was not contented with knowing what former observers had seen, for he began to contrive a telescope eighteen or twenty feet long, and I had to amuse myself with making the tube of pasteboard for the glasses, which were to arrive from London, for at that time no optician had settled at Bath. . . . My brother wrote to inquire the price of a reflecting mirror for, I believe, a five or six foot telescope. The answer was, there were none of so large a size, but a person offered to make one at a price much above what my brother thought proper to give. . . . About this time he bought of a Quaker at Bath, who had made attempts at polishing mirrors, all his rubbish of patterns, tools, hones, polishers, unfinished mirrors, etc., but all for small Gregorians, not above two or three inches in diameter.

"Nothing serious could be attempted, for want of time, till the beginning of June, when some of my brother's scholars were leaving Bath; and then, to my sorrow, I saw almost every room turned into a workshop. A cabinet-maker making a tube and stands of all descriptions in a handsomely-furnished drawing-room; Alexander putting up a huge turning-machine (which he had brought in the autumn from Bristol, where he used to spend the summer) in a bedroom, for turning patterns, grinding glasses, and turning eye-pieces, etc. At the same time music durst not lie entirely dormant during the summer, and my brother had frequent rehearsals at home, where Miss Farinelli, an Italian singer, was met by several of the principal performers he had engaged for the winter concerts. . . . He composed glees, catches, etc., for such voices as he could secure. As soon as I could pronounce English well enough I was obliged to attend the rehearsals, and on Sundays at morning and evening service.

"But every leisure moment was eagerly snatched at for resuming some work

which was in progress, without taking time for changing dress, and many a lace ruffle[1] was torn or bespattered by molten pitch, etc., besides the danger to which he continually exposed himself by the uncommon precipitancy of all his actions, of which we had a sample one Saturday evening, when both brothers returned from a concert between eleven and twelve o'clock, my eldest brother pleasing himself all the way home with being at liberty to spend the next day (except a few hours' attendance at chapel) at the turning-bench; but, recollecting that the tools wanted sharpening, they ran with a lantern and tools to our landlord's grindstone, in a public yard, where they did not wish to be seen on a Sunday morning. But my brother William was soon brought back fainting by Alexander, with the loss of one of his finger-nails. . . .

"My time was much taken up with copying music and practising, besides attendance on my brother when polishing, since, by way of keeping him alive, I was constantly obliged to feed him by putting victuals in his mouth. This was once the case when, in order to finish a seven-foot mirror, he had not taken his hands off from it for sixteen hours together. Generally I was obliged to read to him, while he was at the turning-lathe or polishing mirrors, 'Don Quixote,' 'Arabian Nights Entertainment,' the novels of Sterne, Fielding, etc.; serving tea and supper without interrupting the work, and sometimes lending a hand. I became in time as useful a member of the workshop as a boy might be to his master in the first year of his apprenticeship. But, as I was to take a part the next year in the oratorios, I had for a twelvemonth two lessons per week from Miss Fleming, the celebrated dancing-mistress, to drill me for a gentle-woman (God knows how she succeeded!). So we lived on, without interruption."

On her first public appearance as the leading treble singer in the oratorios, her brother gave her ten guineas for her dress, and on the occasion the proprietor of the theatre pronounced her an ornament to the stage. If she had chosen to persevere, her biographer says her reputation as a singer would have been secure, but, like a woman, she thought more of securing her brother's success than her own. She steadily declined to sing in public unless he was conductor. Besides regular Sunday services, she sang in concerts and oratorios at Bath and Bristol, all the while carrying on her housekeeping with one servant. In this way for ten years at Bath she went on "singing when she was told to sing, copying when she was told to copy, lending a hand in the workshop," and sympathizing with all the intensity of her nature in the course of events, which ended by her brother becoming "the king's astronomer." She sang with him for the last time at Bath, on Whitsunday, 1782.

The following extract narrates the course of events that led to her becoming her brother's constant assistant in his astronomical work:

"My brother applied himself to perfect his mirrors, erecting in his garden a stand for his twenty-foot telescope. Many trials were necessary before the required motions for such an unwieldy machine could be contrived. Many attempts were made by way of experiment against a mirror, before an intended thirty-foot telescope could be completed, for which, between-whiles (not interrupting the observations with seven, ten, and twenty foot, and writing papers

[1] She means her brother's ruffles. In those days lace was worn by gentlemen, and she elsewhere speaks of knitting ruffles for her brother.

for both the Royal and Bath Philosophical Societies[1]), gauges, shapes, weights, etc., of the mirror were calculated and trials of the composition of the metal were made. In short, I saw nothing else and heard nothing else talked of but about these things when my brothers were together. Alexander was always very alert, assisting when any thing new was going forward, but he wanted perseverance, and never liked to confine himself at home for many hours together. And so it happened that my brother William was obliged to make trial of my abilities in copying for him catalogues, tables, etc., and sometimes whole papers which were lent him for perusal. I was thus kept employed when my brother was at the telescope at night. When I found that a hand was sometimes wanted, when any particular measures were to be made with the lamp, micrometer, etc., or a fire to be kept up, or a dish of coffee necessary during a long night's watching, I undertook with pleasure what others might have thought a hardship."

Although the sister's references to the labors and discoveries of her brother are full of interest, we have no space for them here. Suffice it that, after the discovery of "the Georgium Sidus in 1781, the name of William Herschel became famous, and he was soon released from the necessity of giving any of his time to music. He was sent for to come with his seven-foot telescope to the king, and the result was that he was chosen royal astronomer, at a salary of £200 a year." One or two extracts, from the letters written by William Herschel to his sister during this preliminary visit to London, will give some idea of the intimate relation she held in his life. He writes on May 25th:

". . . . Yesterday I dined with Colonel Walsh, who inquired after you. There were present Mr. Aubert and Dr. Maskelyne. Dr. Maskelyne, in public, declared his obligation to me for having introduced to them the high powers, for Mr. Aubert has so much succeeded with them that he says he looks down upon 200, 300, or 400, with contempt, and immediately begins with 800. He has used 2,500 very completely, and seen my five double stars with them. All my papers are printing, with the postscript and all, and are allowed to be very valuable. You see, Lina, I tell you all these things. You know vanity is not my foible, therefore I need not fear your censure. Farewell.

"I am your affectionate brother, WILLIAM HERSCHEL."

And again, June 3d, he writes:

"DEAR LINA: I pass my time between Greenwich and London agreeably enough, but am rather at a loss for work that I like. Company is not always pleasing, and I would much rather be polishing a speculum. . . . I am introduced to the best company. To-morrow I dine at Lord Palmerston's, next day with Sir Joseph Banks, etc., etc. Among opticians and astronomers nothing now is talked of but *what they call* my great discoveries. Alas! this shows how far they are behind, when such trifles as I have seen and done are called *great*. Let me but get at it again! I will make such telescopes and see such things—that is, I will endeavor to do so."

The letter ends abruptly.

Such, in brief, was the intellectual and moral preparation of Miss Herschel for the life of an astronomer. An account of her experiences in this field will be given in our next number.

[1] He was elected a Fellow of the Royal Society December 6, 1871.

CORRESPONDENCE.

LEX TALIONIS.

To the Editor of the Popular Science Monthly.

THE authors of "The Unseen Universe" tell us, as appears in a note in your January number, "It is probable that, before many years have passed, electricity will be called upon by an enlightened Legislature to produce absolutely indescribable torture, thrilling through every fibre of such miscreants"—in referring to "human brutes who vent their despicable passions in murderous assaults on women and children."

Evolution by reversion is not encouraging.

The refinement of scientific training, indicated by the above extract, is hardly in the direction of improving civilization.

It is suggested that the "human miscreants" are not the products of accident. May they not be examples of inherited disease, and therefore properly fit subjects for insane asylums, or other similar reformatories? How far may not society itself, in the locality of these human monsters, be responsible for their existence?

May we not hope that an "eye for an eye" is, in the order of healthy evolution, to disappear entirely from our penal correctives, including that relic of barbarism, capital punishment, even now rapidly disappearing from our statute-books, and in most States inflicted only for one grade of crime?

What is the object of all rational punishment? Certainly not vengeance—not vindictiveness.

Is it not, rather—1. Restitution to society or to individuals, so far as possible, for loss or injury caused by criminals? 2. Protection of society from repetition of criminal acts? and, 3. Reformation of the culprit?

If the gallows, and "absolutely indescribable torture, thrilling through every fibre," provided by *enlightened* Legislatures, are the only infallible remedies, then, indeed, is our vaunted civilization a sad failure.

Let us *revert* to scientific inquisition at once, and have a commission of *savants* in this Centennial year of grace, to resurrect the beauties of Torquemada. Why not?

B.

RICHMOND, INDIANA, *January* 10, 1876.

EDITOR'S TABLE.

MARTINEAU'S REPLY TO TYNDALL.

ONE of the great characteristic elements of scientific knowledge is that it is progressive, and the nature of that progress is to arrive gradually at the establishment of truth. Science having fixed upon its methods—methods that have been vindicated in its history—goes on with the exploration of phenomena in all fields, by beginning with imperfect evidence and gradually working out its investigations to the completeness of proof and the firm establishment of facts and principles. This being so, it follows that those who lead in science, who are active in its preliminary work, are naturally the most obnoxious to all those classes who rest contented with the existing state of opinion and are the conservators of traditional belief. It has always been so. In every phase and stage of advancing science, it is those that push on with the pioneer work, who begin to question opinions long rooted, trusting to the wholesomeness of inquiry, and the validity of long-tested scientific procedure, that encounter denunciation as disturbers of the world's intellectual peace. It was those who initiated in-

vestigation in astronomy, geology, physiology, and the various branches of natural phenomena; and it is those who are now pushing scientific methods of thought into fields where they have hitherto been unrecognized, that are most obnoxious to criticism as meddlers, disturbers, and destructives. The world at length accepts the work, and when it is accomplished will even applaud those who began it; but it as yet by no means recognizes the necessity of sharper questioning, of exploration in new fields, of a more inexorable scrutiny of old opinions, or the necessity of accepting the initial work of pioneer thinkers as legitimate and indispensable.

And so it is that intrepid scientists like Prof. Tyndall, who push on the front and give battle right and left, must take the consequences, as their predecessors have done in the past. The President of the British Association took a step forward at Belfast, and has been in hot water ever since. He assumed the broad, advanced ground that the exploration of the universe, so far as it is accessible to human faculties, belongs to science; and that every system, doctrine, or belief, that has hitherto been put forth regarding the nature, origin, or government of the universe which lays claim to the character of knowledge, must submit its pretensions to be passed upon by the tribunal of science. Science having given to man the universe as we know it, has established its claim to be intrusted with the whole field of intellectual exploration into its methods and laws. It was undoubtedly a bold step for President Tyndall to take, but it was inevitable by the logic of the history of thought. That the batteries should have been opened upon him all around was quite natural, and is but the repetition upon a somewhat larger scale of what has been going on in a smaller way ever since the scientific study of Nature began.

One of the controversies which grew out of the position taken by Tyndall, before the British Association, was with Dr. James Martineau, who is carrying it on vigorously and expansively. He first attacked the Belfast Address in a discourse entitled "Religion as affected by Modern Materialism," delivered to the theological college of which he is principal. To this Prof. Tyndall replied in a new preface to the "Fragments of Science," which appeared in the MONTHLY of last December. Dr. Martineau now rejoins in the February *Contemporary*, in an elaborate article, with more to come. We should be glad to print his paper if it were within limits practicable for the MONTHLY. But twenty-three pages, with the expectation of as many more, would consume more space than we can spare, and it is of less importance that we should issue it, as Mr. Putnam, Dr. Martineau's American publisher, will shortly furnish it to interested readers.

We may, however, briefly take note of Dr. Martineau's general position. He assumes that mischiefs arise, to both science and theology, from confusing their boundaries, and these he attempts to define. He seems to regard them as coördinate departments of investigation, and "that, in their dealings with phenomena, science investigates the 'How,' and theology the 'Whence.'" But on this view theology becomes obviously but one division of science, and is swallowed up by it. In investigating the "how" of things we are simply inquiring into one phase of their order, and in investigating their "whence" we are but inquiring into another phase of the same order. Moreover, we are finding that the investigation of the "how" involves the investigation of the "whence;" so that both procedures are directed to the solution of a common problem. Where are the defining boundaries when one thing is lost in another?

The more common theological position takes the "whence" out of the

field of scientific inquiry by relegating it to the supernatural, and assuming it to be settled by an infallible preternatural inspiration, which is above the sphere of science that deals only with the natural. Orthodoxy plants itself upon the divine, infallible record, which by its nature and source is claimed to be above the reach of science. But Dr. Martineau is heterodox and cannot take this ground. His position is, that the Bible is sacred, but not infallible—sacred like the sacred books of other religions. He says: "I am asked how, after giving up the Old Testament cosmogony, I can any longer speak of 'sacred books,' without informing my readers where to find them . . . . Can a literature, then, have nothing sacred unless it be infallible? Has the religion of the present no roots in the soil of the past, so that nothing is gained for our spiritual culture by exploring its history and reproducing its poetry, and ascending to the tributary waters of its life? The real modern discovery, far from saying there is no sacred literature, because none oracular, assures us that there are several; and, notwithstanding a deepened, because purified attachment to our own 'origenes' in the Jewish and Christian Scriptures, persuades us to look with an open reverence into all writings that have embodied and sustained the greater pieties of the world."

By this position the absorption of theology into science is complete. For if Christianity has no other or different claims for the validity of what it offers than half a dozen other religions have—and impliedly a hundred other religions—what remains but to accept the phenomena of religions as a part of the phenomena of Nature open to scientific exploration? And, if thrown upon Nature, we encounter unity and evolution, and must study the genesis of religious beliefs, the development of superstitions, and the derivation of theological systems, as we study the unfolding of life, or the origin and progress of human institutions. The underlying principle of evolution is continuity, the lowest being connected with the highest by unbroken lines of unity and causation. But though committed, as we think, to this view by the position he has taken, Dr. Martineau affirms a break in the upward movement, so abrupt and total that science cannot cross it. He says, "Nature, in respect of its higher affections, compassion, self-forgetfulness, moral obligation, is constructed in harmony with a world divinely ruled," and this is the sphere of intuition and theology where science does not belong. But does the divine rule necessarily rule out science? and are not intuitions in this higher realm as open to be inquired of scientifically as instincts in the lowest sphere? The writer's declarations that it is the office of theology to explore the "whence" of things, and that it pertains to the "upper zone" of human nature, do not quite clear up the confusion of its boundary relations to science.

Dr. Martineau labors to point out, in his present essay, the difficulties that the "materialist" must encounter in explaining things by the atomic hypothesis; and in his next article he promises to show the deficiencies of the dynamic hypothesis for the same purpose. It is unnecessary to say that, as a writer, Dr. Martineau is an accomplished master of rhetorical effect.

A LIBEL UPON THE INDIANS.

It is an interesting question how the different races of mankind rank as liars. Is the capacity to falsify a constant quantity in all the varieties of men, or does it vary like other qualities; and, if variable, is it subject to development, and how do the various tribes of men stand upon the scale?

A United States Senator has given us his decisive *dictum* upon the subject, and there ought to be wisdom in a sena-

torial *dictum*. Mr. Windom, of Minnesota, is reported as recently saying in the Federal Senate that "the Indians are the greatest liars and vagabonds upon the face of the earth." With their rank as vagabonds we have no immediate concern, but in regard to their grade as liars we think the Senator is in error; he is over-modest; the "greatness" which he so freely accords to the savages, in this respect, belongs preeminently to his own race. The rivalries of falsehood between races, like other rivalries, must depend upon capacity, culture, and opportunity; and, in any competition for honors in deception, the Yankee has proved from the beginning to be much "smarter" than the Indian. Our Senator, indeed, if the reports can be trusted (and they are white, not Indian reports), might be taken as a living and conclusive illustration of the superiority of the superior race in perpetrating falsehood on an imposing scale. He is said to have advocated a breach of the treaty by which the "Black Hills" are reserved to the Sioux, so as to let in all the white adventurers that choose to go there; that is, to break the faith and pledge of the Government, and turn the whole nation into liars by virtue of our representative system. This brings out the exalted advantages in the practice of falsification possessed by the dominant race over the uncultivated savages. We can perpetrate deceit by official machinery. Even in the smallest way, in the hand-to-hand competition of a huckstering trade, the Yankee may be trusted anywhere to circumvent, that is, to outlie the Indian. But when we consider the case in its broader aspects, where the two sorts of people work freely in their separate social spheres, the Indians are not to be named as competitors of the whites in the art of mendacity. Granting the disposition, they lack the resources and capacity. Mentally, they are children, with but little knowledge, scanty ideas upon a few subjects, and limited intellectual operations. They lack the scope, the cultivation, the facilities for exercise in deceit which are possessed by the civilized race. Without books, newspapers, advertisements, highly-organized party politics, diplomacy, lawsuits, complex business rivalries, sectarian strifes, big enterprises, and fashionable society, what can they do in the way of duplicity, fraud, imposition, misrepresentation, artifice, cheating, forgery, perjury, and the thousand forms, and grades, and variations of lying, in which the dominant race is so proficient? The civilized man multiplies his capacity of falsehood through division of labor. He not only lies with his tongue, but with his hands, manipulating falsehood into his manufactures. He lies by machinery, and swindles by steam. By the printing-press he scatters deceptions like snow-flakes over the continent. Your civilizee lies with enterprise, through an army of agents by post and by telegraph. What can the "poor Indian," with his "untutored mind," do in comparison with this? There was more lying in the management of the Northern Pacific Railroad than ten tribes of Indians could perpetrate in a generation. There is more lying in one presidential campaign than all the North American tribes could perpetrate in a century. The Indians are no more "the greatest liars on the face of the earth" than they are the greatest lawyers, politicians, editors, merchants, and manufacturers, on the face of the earth. Fraud, falsification, dissimulation, insincerity, trickery, overreaching, and the innumerable grades and shades of humbug, are vices of the civilized man, and he must accept this with all his other forms of greatness. The Indian has undoubtedly a rudimental capacity for lying, which gets somewhat developed along the borders, by his intercourse with the whites, but he cannot aspire to the unenviable eminence which Senator Windom ascribes to him.

HOW SCIENTIFIC EDUCATION IS EVADED.

Of the two great phases of educational reform, the improvement of its quality, and the increase of its quantity, in our judgment, as we have frequently said, the former is much the most important. We have abundant evidence on all sides as to how easy it is to extend education, or that which passes under its name. And the evidence is equally abundant and clear of the great difficulties of improving the quality of that which is established under the name of education. And the more it is extended and organized, and officialized, the more formidable are the obstacles to any change of method that shall make it increasingly rational. A fresh illustration of the tenacity of traditional ideas, and the ingenuity with which reforms of great and conceded importance are evaded and turned to naught, was lately furnished by Sir John Lubbock in pointing out the tactics of the leading English universities by which the study of science and the modern languages is escaped. To show how the subject stands as a matter of *reason* he first called attention to the views put forth by the several English commissions appointed to inquire into the management of the higher institutions. The commission of 1861, which took up the great public schools, reported that more time should be devoted to the study of modern languages, while, as regards science, that it was practically excluded from the education of the higher classes in England. "Education," they say, "is, in this respect, narrower than it was three centuries ago, while Science has prodigiously extended her empire, has explored immense tracts, divided them into provinces, introduced into them order and method, and made them accessible to all. This exclusion is, in our view, a plain defect, and a great practical evil. It narrows unduly and injuriously the mental training of the young, and the knowledge, interests, and pursuits, of men in maturer life. Of the large number of men who have little aptitude or taste for literature, there are many who have an aptitude for science, especially for science which deals, not with abstractions, but with external and sensible objects; how many such there are can never be known, as long as the only education given at schools is purely literary, but that such cases are not rare or exceptional can hardly be doubted by any one who has observed either boys or men."

In 1868 another commission was appointed to examine the management of the English endowed schools. In their report they say: "We think it established that the study of natural science develops, better than any other studies, the observing faculties, disciplines the intellect by teaching induction as well as deduction; supplies a useful balance to the studies of language and mathematics, and provides much instruction of great value for the occupations of after-life."

Finally, a third commission was appointed, under the presidency of the Duke of Devonshire, to inquire into the state of scientific instruction in Great Britain, and they report that "though some progress has no doubt been achieved, and though there are some exceptional cases of great improvement, still no adequate effort has been made to supply the deficiency of scientific instruction pointed out by the commissioners of 1861 and 1864. We are compelled, therefore, to record our opinion that the present state of scientific instruction in our schools is extremely unsatisfactory."

These are well-matured views put forth with the weight of a large number of the most eminent names in England. The claims of scientific men for time to be devoted to scientific studies have been moderate. Assuming the number of study-hours in a week

to be thirty-eight, Dr. Hooker, Prof. Huxley, and Dr. Carpenter, ask only for six hours to be devoted to science, while Prof. Tyndall demands only eight. The recent commission has shown by a large number of returns from the endowed schools that, when science is studied at all, not more than two hours a week are given to it, while in a large number it is entirely ignored. Out of one hundred and twenty of the larger endowed schools, in more than half no science whatever is taught, and out of the whole number only thirteen attach any weight at all to scientific subjects in the examinations.

It is by the skillful working of these "examinations" that the adherents of the older studies resist the educational progress of science. The Universities of Oxford and Cambridge, backed by the immense authority of these great institutions, have recently appointed a joint board to undertake the examinations of schools. The studies are distributed in four groups: 1. The languages; 2. Mathematics; 3. Scripture knowledge, history, etc.; 4. The sciences. But the certificates are awarded under such conditions that the modern languages and the sciences are virtually suppressed. As Sir John Lubbock says, "the result will be to discourage the teaching of French and German," while "the nominal introduction of science is under the circumstances little more than a hollow mockery;" the effect being that "boys may obtain university certificates while they know nothing of history, nothing of geography, nothing of any modern language, or of any branch of science."

VIVISECTION VINDICATED.

THERE was a loud and passionate outcry a year ago in England, which had its echoes in this country, about the fiendishness of physiologists in their experiments upon living animals. They were represented as devoid of all humanity, indurated and indifferent to suffering, and as delighting to torture poor dumb creatures for mere amusement or class-room show, and on the most frivolous pretexts of helping on the progress of science. There was a great deal of screaming about it, and Hutton, of the London *Spectator*, led the crusade, demanding governmental interference to restrain the brutalities of the scientists and protect the helpless victims of their barbarity. And so, as is wont with the English, a commission was appointed to inquire into the matter, and Hutton was among the commissioners. It was a sensible body, and raked together every thing that claimed to be evidence upon the subject. Of course, the stories of horrors which got such wide credence, turned out to be absurd exaggerations. Brought to book, the secretary of the "Royal Society for the Prevention of Cruelty to Animals" acknowledged that he did not know a single instance of wanton cruelty. The case of the agitators broke down signally, and after the most patient examination of the whole subject the commissioners declare that "a general sentiment of humanity on this subject appears to pervade all classes in this country." They point out how much science is indebted, and how much the world owes, to experiments upon living animals, and they recognize that in the further progress of medical science this means of knowledge cannot be avoided. The commission, in fact, accepts the position taken by the physiologists themselves at the British Association in 1871, and demands only "the reasonable superintendence of constituted authority." The legislation asked for will not in any way alter the existing facilities for research or impede its progress, while it will calm needless apprehension, and put an end to the odious misrepresentations which have recently been rife upon the subject. Perhaps the friends of the lower animals, who have been so ardent in attacking and denouncing

men of science, will now turn their attention to the butchers, the hunters, and the fashionable people who torture their horses in the broad day in the open streets, and at all hours, in the sight of everybody, by the use of bearing-reins and gag-bits.

LITERARY NOTICES.

DESCRIPTIVE SOCIOLOGY. By HERBERT SPENCER. Numbers Three and Four. Folio. Price, $4.00 per No. D. Appleton & Co.

To those who care only for politics on account of its gossip, personalities, and passing excitements, or who study it merely as an art for the attainment of their own selfish ends, these works need not be commended; but those who are interested in working out the principles of a science that underlies all politics will be glad to learn that the "Descriptive Sociology" of Herbert Spencer is making fair progress, the fourth number being now published. This work is not at all known even by the most intelligent portion of the American people. They talk much about society, speculating upon its origin, declaiming against its evils, and proposing endless nostrums for its relief and regeneration, but give no attention to the most serious, thorough, and successful effort yet made to elucidate the natural laws of social phenomena. If the value and importance of Spencer's "Descriptive Sociology" were at all understood, it would be found in every public library, in many private ones, and in all higher educational institutions. It is nothing less than a series of representations, almost pictorial in their clearness, of the constitution of human societies, of all forms, types, and grades, the world over. It gives the whole range of social facts that characterize each community in such an ingenious scheme of representation that they can be compared with extreme facility, and their elements considered either separately or as existing together; and either as advancing by themselves, or as moving on connectedly and under mutual influence. The industrial, economic, domestic, civil, military, æsthetic, moral, religious, and intellectual condition of each community, is given in a systematic way, which brings out the relations of these social factors; and the whole is carefully authenticated by copious and classified extracts from the best authorities by which the social facts in the several cases have been described. Without critical examination no one can form an idea of the enormous labor that has been expended upon these works, nor of their value to the students of social affairs. Nothing worthy the name of social science, that is, embracing wide inductions and comprehensive principles, can ever come from the examination of one example or form of society only; and, in the wide sweep of his inquiries, Mr. Spencer is the first to have given to the problem of social philosophy its full breadth of scientific basis.

In the first number of this general work Mr. Spencer gave us the social history of England. In the second number he gathered up and organized what is known of the social life of the extinct or decayed American civilizations. Number Three, now before us, is devoted to the lowest types of the social state—the Negritto races and the Malayo-Polynesian races. This was compiled and abstracted by Prof. David Duncan, a collaborator with Mr. Spencer in the execution of his enterprise. It represents the social life of the Fuegians, Andamans, Veddahs, Australians, Tasmanians, New Caledonians, New Guinea people, Fijians, Sandwich-Islanders, Tahitians, Tongans, Samoans, New-Zealanders, Dyaks, Javans, Sumatrans, and Malagasy. The environments, inorganic, organic, and sociological of these communities, and the physical, emotional, and intellectual characters of each people are given, and whatever is known or accessible regarding their social habits, peculiarities, and modes of life.

Number Four, which is just published, also elaborated by Prof. Duncan, is devoted to the African races. He delineates the social aspects of the Bushmen, the Hottentots, the Damaras, the Bechuanas, the Caffirs, the East Africans, the Congo people, the Coast Negroes, the Inland Negroes, the Dahomans, the Ashantis, the Fulahs, and the Abyssinians.

We cannot republish these works in the MONTHLY, although in the number for April, 1874, we gave a sample of the tables that are used, and which necessitated the large folio form of publication. But those who

will take the pains to consult and compare these works now issued will quickly see that we are entering upon a new stage of social ideas and knowledge. "The proper study of mankind is man," but it is far from being the same study in different ages.

A TEXT-BOOK OF HUMAN PHYSIOLOGY. Designed for the Use of Practitioners and Students of Medicine. By AUSTIN FLINT, Jr., M. D. Illustrated by Three Lithographic Plates and 313 Woodcuts. Pp. 978. Price, $6. D. Appleton & Co.

THIS work is an abridgment or condensation of Dr. Flint's large treatise upon physiology, in five volumes. The bibliographical and historical features of the larger work are mostly omitted, and various subjects, which are there much elaborated, are more concisely presented in the single volume. The more extensive treatise will retain its place for purposes of reference, as giving a full account of the literature of physiology, and a systematic representation of its facts and principles. Out of this Dr. Flint has educed a complete working manual, which brings the treatment of the subject within convenient limits for students, while it is much more complete as a representation of the present state of the science than any other book we know upon this topic. A marked feature of the work is its illustrations, which are large and especially fine. Many of them are new, and all are executed in the best style of the engraver's art. The book is beautifully printed and is most attractive in appearance; it may be commended to all who desire a comprehensive and trustworthy work up to the latest date, by authority, on the interesting and important subject of physiology.

ANIMAL PARASITES AND MESSMATES. By J. P VAN BENEDEN, Professor at the University of Louvain. With 83 Illustrations. Pp. 274. Price, $1.50. D. Appleton & Co. No. XIX. of the "International Scientific Series."

WE give in the body of the MONTHLY a sample of the curious and interesting information on the economy of animal life to which this book is devoted. It opens a new chapter of strange things in the field of life, to the common reader, and will be perused with avidity by all lovers of natural history. The names of most of the little creatures described will be found somewhat new to general readers; but the lively, familiar, and graphic style of the writer will go far to compensate for this drawback, as he is not without a very decided sense of the comical and humorous side of his remarkable subject. The author is an eminent authority in zoölogy, and the work is largely the result of his own observations and studies. It is one of the most original monographs in the series to which it was contributed.

LIFE HISTORIES OF ANIMALS, INCLUDING MAN: OR, OUTLINES OF COMPARATIVE EMBRYOLOGY. By Dr. A. S. PACKARD, Jr. New York: Henry Holt & Co., 1876. Pp. 243. Figures 268.

SINCE the translation of Siebold's "Comparative Anatomy of the Invertebrata," by Dr. Burnett, accompanied by the valuable investigations of the translator, and the publication of "Mind in Nature," by Prof. H. James Clarke, there has been no general work published in this country equaling in importance the one before us. Indeed, we cannot now recall any work which covers the same ground; and as an evidence of its value it may be stated that the English magazines of science have repeatedly made liberal quotations from some of the chapters, as they originally appeared in the *American Naturalist*.

Dr. Packard has not only brought together and richly illustrated a *résumé* of the labors of the leading embryologists of Europe—Kowelevsky, Schultze, Schneider, Metschnikoff, Salensky, Cienkowski, and others equally distinguished—and also the work of American naturalists, too, but has contributed much original matter from his own published works on insects and crustacea. The various classes are conveniently but not too rigidly grouped in a natural sequence, commencing with the *Monera*, and ending with *Man*.

It is refreshing to get hold of a general work which is strictly in accordance with the latest interpretations of science, and it must remain for many years the one standard work on the subject.

The author, as is the case with ninety-nine hundredths of the leading investigators, is an evolutionist, and indeed it would be difficult to conceive a work of this na-

ture presented in any other light, unless it were given as a bare descriptive catalogue of details.

With each group (considered as a special study) are given a brief sketch of the structure and habits of some of its leading forms, their affinities, embryology, and a very useful table of the literature of the subject. A list of the authors referred to indicates clearly how few Americans have contributed to a knowledge of the subject.

The advanced character of the work is seen in the adoption of Haeckel's terms for different conditions of the embryo, such as the *morula stage*, *planula stage*, *gastrula stage*, etc. The ascidian stage is also recognized in the development of Vertebrata. *Amphioxus* is considered separately from the fishes, the *Brachiopoda* are placed among the worms. Altogether it forms one of the most valuable works of science yet published in this country, and it is safe to say that no working naturalist can do without it.

As a second edition of the work must soon be demanded, we trust it may be accompanied by a table of contents.

ABSTRACT OF RESULTS OF A STUDY OF THE GENERA GEOMYS AND THOMOMYS, WITH ADDENDA ON THE OSTEOLOGY OF GEOMYIDÆ. By Dr. ELLIOT COUES. Washington: Government Printing-Office, 1875. Pp. 74.

THIS is a reprint from Major J. W. Powell's report of his explorations of the Colorado River, giving a full scientific account of the little animals known on the Western prairies as Pocket *Gophers*. Regarding the two genera *Geomys* and *Thomomys* as constituting a perfectly natural group of the grade of a family, *Geomyidæ*, the author describes them as "among the heaviest for their inches of any animals in this country, of squat, bunchy shape, with short, thick limbs, a short tail, very small or rudimentary ears, small eyes, no appreciable neck, and thick, blunt head; and they are as completely subterranean as the mole itself. They are rarely or momentarily seen above the ground; they excavate endless galleries in the earth in their search for food, frequently coming to the surface to throw out the earth in heaps, but plugging up these orifices as soon as they have served their purpose."

Geomys contains five (some authors say seven) well-defined species; *Thomomys* but a single species, including three recognizable races, out of which, by the process of species-mongering so common with earlier naturalists, a dozen separate species were made. While in *Geomys* the links have disappeared and the species are well-pronounced, in *Thomomys* the separation is incomplete, and the connecting forms still visible. "The genus appears to be working into a number of species, but the process is still far from completion." Adopting modern philosophical views, the author's tendency is to reduce the number of species, seeing only races or varieties where others claim to have found well-defined species. The several species constituting the family are separately described. The cranial and dental characters of the group are afterward treated, and the work closes with a further description, communicated by Prof. G. Brown Goode, of *Geomys tuza*, a form confined to Florida, Alabama, and Georgia, and there known as Salamanders.

Prof. Coues has the rare faculty of making even technical descriptions interesting, and for this reason the work commends itself to the attention of other than scientific readers.

PRACTICAL HINTS ON THE SELECTION AND USE OF THE MICROSCOPE. By JOHN PHIN. New York: The Industrial Publication Co., 1875. Pp. 131. Price, 75 cts.

IN the preface to this little book the author tells us that it is intended for beginners in the use of the microscope, a purpose that appears to have been kept well in mind in the subsequent pages, as the explanations are clear, the directions explicit and suitably detailed; and nothing has been attempted that lies beyond the understanding of any intelligent girl or boy of fifteen. After pointing out the numerous applications of the instrument, that are every day extending, the simple and compound microscope, and the essential parts of each, are described. The various forms in use are next enumerated, with brief descriptions of the most noted; and then follow practical directions for the selection of a microscope, and the requisite accessory apparatus. Illumination, the manipulation and care of the instrument, and the collec-

tion and mounting of objects, take up the remainder of the book. The student is referred to the larger works of Carpenter and others for a knowledge of the principles involved in the construction of the microscope, and of the course of procedure in the several departments of study to which it is applied.

FOUR THOUSAND MILES OF AFRICAN TRAVEL. By ALVAN S. SOUTHWORTH, Secretary of the American Geographical Society. With Maps and Illustrations. Baker, Pratt & Co., New York. Price, $3.50.

THE volume of Mr. Southworth is an interesting contribution to our knowledge of one of the most important regions of Central Africa. It is the well-told account of a journey made by the author as traveling correspondent of the *New York Herald* for the purpose of exploring the countries of the Upper Nile—their aspects, resources, and populations.

The journey commenced at Cairo on the 27th of December, 1871. "At noon on the 6th of February," says the traveler, "our Soudan *dahabeah* was parting the dark, rippling waters of the Blue Nile from the muddy flow of its sister confluent, the White Nile, and by one o'clock the solitary minaret of Khartoum was seen above the palms and acacias!" This city contains 40,000 inhabitants, is the capital of the Soudan, and is the finest provincial city of Central Africa.

The chapters in which the author gives an account of his trip up the White Nile through the heart of the Soudan are full of interest. The country is described as wonderfully fertile. With its present wretched cultivation it is more productive than the well-tilled fields of Italy. It abounds in cattle and camels, as well as wild animals. Under the present government the progress toward civilization has been immense. Within fifteen years we are informed, 30,000,000 people have been brought in some degree within the circle of semi-civilization. But only incipient steps are taken. The slave-trade and all the depressing influences of savagism still bear upon the people. It is believed that no country in the world is better adapted to the raising of cotton than the Soudan.

The author turned back from his travels at Arbah Island, 300 miles southward from Khartoum, and nearly 2,000 miles from the Mediterranean.

The volume is enlivened by vivid descriptions of natural scenery and phenomena. On the Nubian Desert the mirage sometimes breaks the dreary view. "On the 17th of January we were seemingly encompassed by this imponderable mirror. In the glowing heat the bed of the desert would seem to rise in rippling waves, and a line of rocks, at 200 yards distance, kept common time and looked like a regiment of men marching off the field in line of battle." The simooms, sand-storms, and sand-spouts, as well as the gorgeous tropical scenery, are vividly described. The horrors of the slave-trade, and the means by which this and other barbarisms may be overcome, are prudently and judiciously treated. Dr. Southworth has done excellent service in publishing this volume.

THE AMERICAN JOURNAL OF MICROSCOPY AND POPULAR SCIENCE. Issued by the Handicraft Publication Company, 37 Park Row, New York. Subscription price, 50 cents a year

THIS is a twelve-page monthly devoted mainly to the interests of microscopy. Its purpose, as expressed in the prospectus, is to diffuse a knowledge of the best methods of using the microscope, of valuable improvements in the instrument, and its accessories; of new methods of microscopical investigation, and of the most recent results of microscopical research. Besides general articles, of which the number before us offers a pleasant variety, some of them illustrated, there is a "Young Folks' Column," "Our Work-Table," "Book-Table," "Notes and Queries," etc.

REPORT OF THE MICHIGAN BOARD OF HEALTH, 1874. Lansing: W. S. George & Co. Pp. 254.

AMONG the subjects treated in this report are the entailments of alcohol, drainage for health, poisonous paper, relation of schools to health, resuscitation of the drowned, cerebro-spinal meningitis, meteorology of Central Michigan. Of the eight special reports, five were drawn up by Prof. R. C. Kedzie, M. D., whose labors are well known to all who take an interest in sanitary science.

A GUIDE TO THE MICROSCOPICAL EXAMINATION OF DRINKING-WATER. By J. D. MACDONALD, M. D., F. R. S. Pp. 113. With twenty-four Lithographic Plates. Price, $3. Philadelphia: Lindsay & Blakiston. 1875.

THIS volume is an important contribution to our knowledge of the extent and nature of the impurities found in drinking-water, and the most ready means of detecting and classifying them. In clearness of method and statement, and style of its illustrations, the work is admirable. The author does not attempt to link particular forms of impurity with specific sanitary effects, but says further observation may show their deep sanitary significance.

No one now hesitates to condemn a water containing bacteria and fungi, or swarming with the lower forms of life.

The means by which sediments and floating impurities in water may be best obtained and studied is pointed out in a brief introduction.

Section 1 treats of the mineral matters found in drinking-water; section 2 gives an account of the dead and decaying, section 3 of the living forms found in water.

The twenty-four plates comprise over four hundred figures; frequently, however, the same object is presented under different forms. The volume is an excellent handbook, and will greatly facilitate the study of the important subject of which it treats.

EXPLORATION OF THE COLORADO RIVER OF THE WEST AND ITS TRIBUTARIES IN 1869, 1870, 1871, AND 1872. Washington: Government Printing-Office. Pp. 291.

THIS is the first installment of Major J. W. Powell's exploration and survey of the Colorado River region. The book consists of three parts, in the first of which we have a journal of the exploration of the cañons of the Colorado in the year 1869; in the second, an account of the physical features of the valley of the Colorado; and in the third, three chapters on the zoölogy of the region explored. The two chapters of the second part were published in the MONTHLY last summer, Major Powell kindly permitting us to copy from advanced sheets, and supplying us with the woodcuts. The present volume is an exceptionally interesting and instructive description of the strange and picturesque country explored.

THE CHOLERA EPIDEMIC OF 1873 IN THE UNITED STATES. Pp. 1025. Washington: Government Printing-Office.

CONTAINS reports made to the Treasury Department by Dr. Woodworth, superintendent surgeon of the Marine Hospital Service, and to the War Department by Dr. J. K. Barnes, Surgeon-General U. S. Army. Dr. Woodworth's report is brief, and traces the history of the introduction of cholera through the agency of the mercantile marine. The War Department report is divided into three parts, the first being written by Dr. Ely McClellan, U. S. Army. This gives a history of the epidemic of 1873 in the United States. The second part, by Drs. J. C. Peters and Ely McClellan, is devoted to the history of the travels of Asiatic cholera. In the third part is given the bibliography of cholera by Dr. J. S. Billings, U. S. Army.

NOTES ON CERTAIN EXPLOSIVE AGENTS. By WALTER N. HILL, S. B. Boston: John Allyn, 1875. Pp. 71.

THIS pamphlet contains a large amount of practical information about several of the more important explosives now in common use, such as nitro-glycerine and its various preparations, gun-cotton, and the picrates and fulminates. Their chemical composition, mode of preparation, manner of firing, and the reactions which occur during explosion, are clearly set forth, and tables are also given exhibiting their relative explosive power.

THE TAXIDERMIST'S MANUAL: OR, THE ART OF COLLECTING, PREPARING, AND PRESERVING OBJECTS OF NATURAL HISTORY. By THOMAS BROWN, F. L. S. New York: G. P. Putnam's Sons. Pp. 150. Price, $1.25.

THIS is a practical guide to the art of taxidermy, giving detailed directions for all the operations required in the preparation and mounting of natural history specimens. It contains several plates and a full index.

SOUL PROBLEMS, WITH OTHER PAPERS. By JOSEPH E. PECK. New York: Charles P. Somerby. Pp. 63. Price, 70 cents.

THE problems considered in this essay are the materiality or immateriality of the mind, and future personality. The other papers are on "The Theological Amendment," and "The State Personality Idea."

STARTLING FACTS IN MODERN SPIRITUALISM. By N. B. WOLFE, M. D. Chicago: Religio-Philosophical Publishing House. Pp. 571.

DR. WOLFE tells us that he has been for twenty-five years an observer of modern spiritualism. Had he not published this book, the world might never have known the extent of his gullibility. He has only himself to blame.

CONTRIBUTIONS FROM THE LABORATORY OF THE STATE UNIVERSITY. By P. SCHWEITZER, Ph. D. Jefferson City, Mo.: Regan & Carter. 1875. Pp. 38.

Two papers by Prof. Schweitzer, printed from the Catalogue of the University, comprise this pamphlet. One is upon the "True Composition of Coal," and the other on the "Water-Supply of Columbia, Boone County," with analyses. Both papers are of value, giving in detail the results of faithful and well-directed laboratory work.

VIEWS AND INTERVIEWS ON JOURNALISM. Edited by CHARLES F. WINGATE. New York: F. B. Patterson. Pp. 372.

MR. WINGATE allows some of the prominent newspaper editors of the United States to express their opinions on journalism, its limits, its tendencies, its perils, its prospects. In some instances the editors are catechised in an interview, in others their views are ascertained by reference to the journals they edit.

THE LOWER FORMS OF LIFE FOUND WITHIN THE ORAL CAVITY. By C. N. PEIRCE, D. D. S. Pp. 23. Lancaster, Pa.: *Pennsylvania Journal of Dental Science.*

THE forms of life here spoken of are six in number, five of them being vegetal growths, and the sixth an animal organism, a genus of infusorium. They are all microscopic organisms.

THE PROSPECTOR'S MANUAL. By W. J. SCHOFIELD. Boston: W. J. Schofield & Co. Pp. 96. Price, 50 cents.

INTENDED as a guide to the discovery of quartz and placer indications of gold and silver mines. The book further gives descriptions of metalliferous rocks of various kinds in the New England States and the neighboring provinces of Canada.

JOURNAL OF THE AMERICAN ELECTRICAL SOCIETY. Vol. I., No. 1. Chicago: Lakeside Publishing Co. Pp. 98.

THE American Electrical Society, whose official organ this *Journal* is, has for its object the interchange of knowledge and the professional improvement of its members, the advancement of electrical and telegraphic science, and the establishment of a central point of reference. The articles which appear in the *Journal* consist chiefly of papers read at the meetings of the society, but papers from other sources on telegraphic and electrical subjects are also given. In the present number, the first article, which is well illustrated, is by Mr. Elisha Gray, on "The Transmission of Musical Tones telegraphically." There is also an illustrated article on "Quadruplex Telegraphy." Among the selected articles we may name one on Edison's "New Force," by Dr. Beard, and a sketch of Sir Charles Wheatstone. The Publishing Committee, in a note prefixed to the present number, state that a second number may be issued in three or four months. Price, $1.50 per number.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA (1874). By N. H. WINCHELL. Pp. 36. St. Paul *Pioneer Press* print.

IN this, his third annual report, the State geologist of Minnesota gives the results of his researches on the geology of the two counties of Freeborn and Mower. In the former county there is an abundance of peat, most of the marshes being peat-bearing. This peat is of the best quality, and is gradually coming into use for fuel. Geological maps of the two counties accompany the report.

BULLETIN OF THE UNITED STATES NATIONAL MUSEUM. By J. H. KIDDER, M. D. Washington: Government Printing-Office. Pp. 51.

THE present number of the "Bulletin" is devoted to a description of the ornithological specimens brought from Kerguelen Island by the Transit-of-Venus Expedition of 1874–'75. The number of species described is twenty-one, belonging to six families — *Procellaridæ*, *Spheniscidæ*, *Laridæ*, *Phalacrocoracidæ*, *Anatidæ*, and *Chionididæ*.

BULLETIN OF THE BUFFALO SOCIETY OF NATURAL SCIENCES. 1875. Buffalo, N. Y.: The Courier Company, Printers. Pp. 120.

THIS issue is No. 4 of Vol. II., and comprises nine articles, with an index to the volume. The articles are No. 16 to No. 24 of the series, eight of which are upon subjects of entomology, and all of value to specialists in that science.

No. 18 is a check-list of the North American sphinxes by Aug. R. Grote, and No. 20 is a valuable paper by Dr. Scudder, being a synonymic list of the butterflies of North America north of Mexico.

Article No. 22, by M. C. Cooke, M. A., of London, is a synopsis of the discomycetous fungi of the United States, in which very full credit is given to American mycologists for assistance rendered.

NECESSITY OF A MECHANICAL LABORATORY. By Prof. R. H. THURSTON. Pp. 10.

PROF. THURSTON here defines what a mechanical laboratory ought to be, its province and its methods. Such a laboratory the trustees of the Stevens Institute of Technology, he informs us, have consented to establish. Such bodies as the Railway Master-Mechanics' Association, the Society of Civil Engineers, and the Iron and Steel Association, have pledged themselves to give aid and advice in promoting the enterprise.

SOME ACCOUNT OF ZAPUS HUDSONIUS AND LAGOPUS LEUCURUS. By Dr. E. COUES. Washington: Government Printing-Office. Pp. 14.

Zapus is the name given by Dr. Coues to a genus which includes only one species, the "long-legged mouse of Hudson's Bay." This animal, usually referred to the *Muridæ*, differs from the Muridæ, says Dr. Coues, to a degree warranting the recognition of a family *Zapodidæ*. With respect to *Lagopus leucurus* (the white-tailed ptarmigan), Dr. Coues remarks upon its breeding-habits, its nest, and its eggs.

THE MAMMOTH CAVE OF KENTUCKY. By W. S. FORWOOD, M. D. Philadelphia: Lippincott. Pp. 241.

THIS is an excellent account of the great Kentucky Cave. It is not only a trustworthy guide for the visitor, but something far better than an ordinary guide-book—an historical and descriptive account of the Mammoth Cave, giving explanations of the causes concerned in its formation, its chemistry, geology, etc., together with full scientific details of the eyeless fishes. The volume has twelve lithographic illustrations, also an original map.

GEOLOGICAL NOTES. By Prof. WILLIAM B. ROGERS. Pp. 13.

THE two papers contained in this pamphlet are reprinted from the "Proceedings of the Boston Society of Natural History." The first of the papers treats of the Newport conglomerate, and the second of the gravel and cobble-stone deposits of Virginia and the Middle States.

WEIGHTS, MEASURES, AND MONEY, OF ALL NATIONS. By F. W. CLARKE, S. B. Pp. 117. New York: D. Appleton & Co. Price, $1.50.

This is a very useful little volume, enabling the reader to reduce to United States standards the money, measures, and weights of every commercial nation in the world. The work is divided into two parts, in the first of which we have a classification according to countries, arranged alphabetically, and, in the second, a set of tables, giving the value of each unit both in English and in metric standards.

PUBLICATIONS RECEIVED.

Washington Astronomical and Meteorological Observations (1873). Washington: Government Printing-Office. Pp. 429.

Reconnoissance of Northwestern Wyoming. By W. A. Jones, U. S. A. Washington: Government Printing-Office. Pp. 332.

Algebraical Equations. By J. Macnie, A. M. Pp. 194. New York: A. S. Barnes & Co. Price, $2.50.

History of the United States. By J. A. Doyle. Pp. 404. New York: Holt & Co. Price, $1.40.

Beliefs of the Unbelievers. By O. B. Frothingham. New York: Putnams. Price, $1.

French Political Leaders. By E. King. Pp. 326. *Same publishers.* Price, $1.50.

Filth-Diseases. By J. Simon, M. D. Pp. 96. Boston: James Campbell. Price, $1.

Percy Bysshe Shelley as a Philosopher and Reformer. By C. Sotheran. Pp. 51. New York: Somerby. Price, $1.25.

Algebra for Beginners. By J. Loudon, M. A. Pp. 158. Toronto: Copp, Clark & Co.

Report on the Public Schools of Columbus, Ohio. Pp. 428. Columbus: S. A. Glenn.

The Textile Colorist (Monthly). For sale in New York by Wiley & Son. Price, $1 per number.

Report of New York City Superintendent of Schools (1875). Pp. 77. New York: Cushing & Bardua print.

Report on the Harvard Museum of Comparative Zoölogy (1875). Pp. 58. Boston: Wright & Potter print.

Message of Governor Tilden (January, 1876).

Chemical Analyses of Fertilizers. Published by the Georgia Commissioner of Agriculture. Pp. 44.

The Bible and Science. By J. Weiss. Pp. 22. Boston: Cochrane & Sampson print.

Sheep-Husbandry in Georgia. Pp. 24. Atlanta: Harrison & Co. print.

Sympathy of Religions. By T. W. Higginson. Pp. 38. Boston: Free Religious Association. Price, 10 cents.

The Financial Problem. By Hon. E. Ward. Pp. 18. Washington *Congressional Record* print.

Charities of New York (1876). Pp. 69. New York: Putnams.

Sketch of the Life of J. A. Lapham. By S. S. Sherman. Pp. 80. Milwaukee: *News* Co. print.

Man's True Relation to Nature. By T. P. Wilson, M. D. Pp. 26. Cleveland, Ohio: L. H. White.

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Meteorology and Health. By W. Blasius. Pp. 5.

MISCELLANY.

Trichinous Pork.—*Trichina spiralis* was first discovered by Owen, in 1835, in human muscular tissue. Some twenty years later the parasite, as seen by Owen, namely, as a minute worm coiled up within a cyst, was found by Herbst to be the larva of a thread-like worm. The latter passes its life in the intestinal canal, the former inhabits the muscular tissue. When the flesh of animals infested by the larvæ is taken into the stomach, the immature trichinæ quickly multiply, and in the course of a few days millions of the encysted larvæ may be found in the muscles. As has been shrewdly conjectured, it is not improbable that the prohibition of pork as food, a prohibition enforced not only among the Jews, but among various races inhabiting widely-separate regions of the earth, had its origin in an observation of injurious consequences attending the use of swine's flesh. Dr. Sutton's "Report on Trichinosis," noticed in our January number, is worthy of the attention, not only of medical men, but of the public. We give herewith the result of his observations on the cases of the disease which came under his notice, and of his examination of hundreds of specimens of pork:

1. He found that all the cases which came under his observation were produced by eating uncooked or imperfectly-cooked pork. 2. He reiterates the uniform teaching of medical observers that the vitality of the trichinæ can be destroyed only by thorough cooking of the meat, and that the eating of merely smoked or dried pork is dangerous. 3. From microscopic examinations of pork killed in Southeastern Indi

ana, he found from three to sixteen per cent. of the hogs affected with trichinæ, the number of hogs diseased varying greatly in different localities. 4. That ninety per cent. of the disease produced by trichinous pork appears as gastero-enteritis, diarrhœa, or dysentery, ten per cent. only representing the cases of trichinosis proper.

Penetrating Power of Different Colored Lights.—An experiment was lately made at Trieste, to determine how far lights of different colors penetrate darkness. Half a dozen lanterns with carefully-selected glass, and all furnished with oil and wicks of the same quality, were lighted on the beach, and then observations were made by a party in a boat. At the distance of half a league, the dark-blue lantern was invisible, and the deep-blue one nearly so; hence it appears that blue lights are not adapted for use in lighthouses, or as signals. Of all the colors the green was visible for the longest distance, with the exception of the red, which ranked next to the white in power of penetration. The conclusion is, that only the green and the red are suitable for signals; and the green light the Trieste observers only recommend for use in conjunction with white and red lights, inasmuch as, when viewed from a short distance, an isolated green light begins to look like a white one.

Curious Freak of the Curly-Willow.—The following curious facts are communicated by Dr. S. Lockwood to the *Botanical Bulletin:* "We have two pendent willows, known as *Salix Babylonica* (more correctly *S. pendula*, Mœnch.), the weeping-willow, and *Salix crispa*, the curly-willow. On the grounds of Hon. E. W. Scudder, Trenton, New Jersey, is a fine specimen of each, the two having a clear distance of twenty-five feet between their nearest branches. The topmost branch of the curly-willow, on the side of the tree next the weeper, is about ten feet long, and six feet thick, and is densely covered with leaves. The curious fact is, that while the rest of this entire tree has the perfect habit of *S. crispa*, this large branch has the perfect habit of *S. Babylonica*. The long pendent branchlets, and every leaf, are in all respects those of the weeping-willow. This is true not only of the form and habit of the leaves, but with positive exactness also of the color. The true *crispa* leaves are a very dark and shiny green above, and almost a chalky white underneath. The pseudo-*Babylonica* leaves are a pale yellowish-green above, and still paler, perhaps pea-green, on their under sides. I compared them carefully with the leaves of the neighboring *Babylonica*, and, excepting perhaps that the leaves of the freak were a little the smaller, a fact of no significance, there was no difference whatever. Looking at this great branch, the spectator comes to regard it as a natural graft. This is an utter mistake. It is purely an outcropping of heredity, and is thus an interesting evidence of the identity of species in the curly and the weeping willow. Supposing *S. Babylonica* to be the ancestor, we have here the long-dormant inherited force asserting itself, and proclaiming the ancient and wellnigh lost parentage of *S. crispa*. It is observable, too, that the foliage of the branch, thus representing the true weeper, is much more dense than that on the rest of the tree representing the curly-willow. This is the fact respecting these trees everywhere. The curly-willow has this to its disadvantage, its paucity of foliage, so that, in pointing back to its ancestry, it declares the leaf-wealth of the ancient line. As the tree is a very old one, it is significant that this declaration of heredity should appear so late in life."

A Wise Public Benefactor.—In 1868 Sir Joseph Whitworth presented to the British nation an annuity of £3,000 per year, which was vested in the Department of Science and Art, for the purpose of founding scholarships to promote the instruction of young men in the theory and practice of mechanics and the cognate sciences. He has now made over to the public his large landed estates for similar purposes, reserving to himself a life interest. The Department of Science and Art is to hold the estates, subject to the control of Parliament. In commenting upon this munificent action of Sir Joseph Whitworth, the London *Times* commends his wisdom in trusting Parliament to adapt his endowment to the varying circumstances of successive times. "We have had," says the *Times*, "abundant

instances of late years of the manner in which what the Lord-Chancellor describes as a 'perpetual trust' has hampered, instead of fostering, the development of the future. It is not merely that so much money has been wasted, but obsolete rules and exploded systems have been a lasting obstacle to the growth of thought and to the intelligent adaptation of new generations to new necessities. The law of mortmain has not been sufficient to avert this danger, and great institutions like our universities and public schools have from time to time come to a dead-lock. Being established with no other dominant object in view than that of perpetuating the systems of the past, a troublesome outcry has always been raised when it has become necessary to adapt them to the present."

Diffusion of Cholera.—Pettenkofer's theory of the spread of cholera—namely, that it depends on geological and hydrological conditions—receives confirmation from the researches of Dr. Decaisne, one of the foremost hygienists of France. In a communication to the Académie des Sciences, Dr. Decaisne calls attention to the fact that the cities of Lyons and Versailles have always been in a great measure proof against this disease, though the country round about has again and again been ravaged by it. Paris, on the contrary, has often suffered severely from cholera. In 1832 Lyons entirely escaped the visitation of the epidemic, which ravaged all the rest of the country. Again, in 1835, Lyons was not attacked by the cholera in its advance up the Rhone. In 1849 it made its appearance in one of the barracks, and a few cases occurred in the neighborhood; but three weeks later it had disappeared. In the autumn of 1853 the cholera prevailed in the department of Drôme; there was an outbreak at Lyons, the number of cases being 400, with 196 deaths. In 1865 there were only a few sporadic cases.

According to Pettenkofer's theory, the immunity of Lyons is explained partly by the constitution of the soil, but this explanation applies only to those quarters of the town which overlie the granite rock, either directly, or with a bed of clay interposed. All those portions of the city which rest on the alluvium owe their immunity to peculiar conditions of the underground water. The two instances mentioned above of outbreaks of the cholera in Lyons coincide with periods of exceptional drought, when organic matter, which is usually submerged, underwent decomposition by the action of the air. But those portions of the city which owe their salubrity to the physical constitution of the soil have always enjoyed immunity. As for the city of Versailles, the conditions there are analogous to those found at Lyons. But Paris rests on Eocene Tertiary formations which are permeable and dry—conditions which are favorable to the dissemination of cholera.

Coal-Deposits in New York State.—In a recent popular lecture on the subject of coal, given under the auspices of the Buffalo Society of Natural Sciences, Prof. A. R. Grote speaks as follows of the prospects of finding coal within the limits of the State of New York: "Though coal exists in small quantities in the earth below the carboniferous formation, it will not pay to mine it. The Marcellus shale, for instance, is so charged with bitumen that it can be burnt. A great deal of money has been wasted in this State in searching for coal in formations where it could not be found. More money, a thousand times over, has been frittered away than would pay for a new scientific survey of the State, which is so much needed. Instead of consulting scientific men, geologists, people have dug vainly, and wasted time, labor, and money. Within the borders of our State we have no carboniferous formations, except a bare outcropping, in the southwestern part, of conglomerate belonging to the series. No coal exists in this State in any quantity."

Observations on the Migrations of Birds.—With a view to ascertain the conditions governing the migrations of birds and certain other periodical phenomena, the natural-history editor of *Forest and Stream* invites the attention of observers throughout the country to the subject, and suggests that each one keep a record of his observations. The points to be specially observed are the following: 1. Whether each species of birds is resident throughout the year, is a sum-

mer or winter visitant, or only passes over a locality in spring or fall. 2. With reference to each species in a given locality, whether it is "abundant," "somewhat common," or "rare." 3. What species breed, and whether more than once in a season. 4. Dates of arrival, greatest abundance, nest-building, laying eggs, hatching of young, and beginning of departure of each species, and when it is last seen in the fall. 5. What effects, if any, upon the relative abundance of particular birds, in retarding their arrival or hastening their departure, sudden changes of the weather, storms, and late and early seasons appear to have. 6. Similar notes upon the appearance and movements of the quadrupeds, reptiles, and fishes of the region, and upon the time of flowering of trees and plants. 7. Other occurrences considered noteworthy. It is desirable that records of this kind should be kept. As the writer in *Forest and Stream* observes, it is through such observations as these, continued year after year, that the natural history of England has become so well known, and so many persons there have become interested in it. We may add that children might easily be induced to take an interest in this kind of natural-history observations, and so by degrees acquire the faculty of accurately noting what is going on around them.

Arctic Research.—A commission of thirteen eminent naturalists, appointed by the German Government to discuss the question of Arctic discovery, have made a report, in which they adopt the advice of Lieutenant Payer, of the Austrian Expedition. They do not object to Arctic research, but dissuade from voyages of discovery; they believe that the advantages to be derived from the former can be secured by a safer and surer method. They recommend the establishment of permanent stations in those Arctic regions which can be safely approached and abandoned at any time. As a beginning, they recommend several stations to be formed on the eastern shore of Greenland, the western shore of Spitzbergen, and Jan Mayen Island. Houses should be built, furnished with every regard to the inclemency of the climate. In each house the commission would have stationed a detachment of scholars, sailors, and other enterprising men, to remain for a term of years, a ship being sent out for their relief from time to time.

The men at these stations could do good work for meteorology, by observing the periodic recurrence of Arctic phenomena, as well as any deviation from the ordinary rule, and would thus be enabled to discover the reasons for the alternation of storm and calm at the equator. The connection between terrestrial magnetism and atmospheric electricity, cable-currents, and the aurora borealis, can only be investigated in such high latitudes; while the laws of terrestrial magnetism itself will never be thoroughly appreciated unless the variations of magnetism in the far north are studied. Then as to astronomy, the theory of refraction, the atmospheric lines of the spectrum, and the relation between comets and shooting-stars, to be better known, require continued observation near the pole. Geodesy, too, by measurement of degrees and observation of the pendulum, will arrive at more definite conclusions respecting the form of the globe.

Geography, independently of the topographical details to be ascertained on the spot, will derive the most valuable geognostic information from further systematic study. Geology, paleontology, mineralogy, botany, and zoölogy, may expect to make great strides from persistent exploration of the northern and southern poles, while physiology and biology will be enormously advanced by the discovery of the conditions of life in those cold regions. There was a time when man in Central Europe led the life to which Lapps and Eskimos are condemned nowadays. To become familiar with the manners and customs, the religion and morals, the physical and psychical peculiarities of Arctic races, is to dive into the distant past, and may probably explain much that is still unintelligible in our primeval history.

Force and Work.—Work without implies work within. No exercise of force can be made except by the generation and use of force of which no part enters into the external result. The use of muscles in-

volves use of nerves. The external force, if exerted by a muscle, is only part of that which it produces. Now, the proportion between these two in their several degrees is a subject of great practical importance, and some interesting facts have recently been published by Helmholtz. From these it is clear that the greater the external force exerted the greater is the proportion of the needful internal force—that is, great exertion is more wasteful than moderate exertion. Then force has to be evolved in proportion to the external work done, and therefore the greater is the wear and tear of the animal machine. The same increased proportion of non-productive work is seen when the external energy is below a moderate amount. It is found, for instance, that in walking, a speed of three miles an hour gives the most economical use of the forces. No doubt in these facts we have an index to much of the ill effects of the present high-pressure rate of work and life. The waste of force is out of proportion to the work done. More is effected in a given time, but the body feels it more, and its working period is proportionately shorter. These facts cannot be too often repeated or too constantly remembered by those who have the regulation of labor.—*Lancet.*

Contributions to Meteorology.—The *American Journal of Science*, for January, contains the fourth paper by Prof. Loomis, giving results of recent researches in the science of meteorology, founded on data derived chiefly from the weather-maps of the United States Signal Service.

In a former article attention was called to the fact that low temperatures at the surface of the earth are produced by descent of *cold air from the upper regions of the atmosphere.* It was shown that, in areas of high barometer, the movement of the air is outward from the centre, instead of inward, as in case of low barometer or storm. This implies a supply from downward motion.

The current notion, that extreme cold is brought by wind from colder areas, is met by the fact that, at Yakootsk, in Siberia, which is about the coldest place in the Northern Hemisphere, the temperature is lowest when the air is quite still, and equally when the wind is from north, south, east, or west. These results are obtained from four years' observations at that place, and are similar to those obtained at New Haven, except as to direction of wind. It would be difficult to explain where the extreme cold of Yakootsk came from, except from the upper atmosphere, seeing that it is colder than the country round about.

A diurnal variation in the progress of storms was noticed by Prof. Loomis in a former paper. This fact suggested to him the further one that there is a diurnal inequality in the rainfall. This is now shown by observations made at Philadelphia, not by the Signal Service maps, which do not record hourly observations. It appears that the maximum rainfall occurs at about six o'clock in the afternoon; and the minimum at three o'clock in the morning.

By observations which cover a period of ten years, made at Prague, in Bohemia, it appears that the greatest rainfall during the day occurs in the afternoon, the maximum being from three until six o'clock.

The tracks of storms in America and Europe, already noticed by Prof. Loomis, are further considered in this paper. He determined the precise latitude at which the storm-centres cross certain lines of longitude, and in this way establishes a line which is the track of the storm-centre; a similar method was applied to storms in Europe. It appears that the average track is not regular, but varies. In an article published in July, 1874, it was stated that the average direction of the storms of the United States was, for the year, 8° north of east, and that is correct as a general statement. Connected with the present article is a chart, by which it is seen that the average track of American storm-centres is over Chicago and Detroit, and is deflected to the south coast of Newfoundland. From this point it seems to be continuous over the ocean, being deflected northward near the Irish coast, passes over Dublin, and thence across Denmark. These results, however, are obtained from the Paris maps, and the continuity of the line may, in some measure, depend on the extent of the field of observations by which it was determined.

The number of storms traced across the Atlantic Ocean is not large; they undergo changes on the ocean, and frequently are merged in other storms.

The velocity with which storms advance is further considered in this paper. It was previously stated that the rate might vary from a stationary condition for many hours, or several days, to the extreme velocity of 1,200 miles in a day, or even 57.5 miles an hour.

By an examination of European maps it appears that storms over Europe travel at an average rate of 26.7 miles per hour, and it was found from examination of American maps that they move at about the same rate in this country. But over the Atlantic Ocean the movement is only 19.6 miles, showing that the velocity is less over the ocean than over the land.

This proves that the progress of a storm is not merely a drifting of the atmosphere; for, observes the professor, it seems probable that the average progress of the atmosphere in an easterly direction is as rapid over the Atlantic Ocean as it is over North America.

How Rats and Mice use their Tails.—To test the correctness of the popular belief that rats and mice use their tails for feeding purposes, when the food to be eaten is contained in vessels too narrow to admit the entire body of the animal, a writer in *Nature* made the following experiments: Into a couple of preserve-bottles with narrow necks he put as much semi-liquid fruit-jelly as filled them within three inches of the top. The bottles were then covered with bladder, and set in a place frequented by rats. Next morning the covering of each bottle had a small hole gnawed in it, and the level of the jelly was lowered to an extent about equal to the length of a rat's tail if inserted in the hole. The next experiment was still more decisive. The bottles were refilled to the extent of half an inch above the level left by the rats, a disk of moist paper laid upon the surface, and the bottles covered as before. The bottles were now laid aside in a place unfrequented by rats, until a good crop of mould had grown upon one of the moistened disks of paper. This bottle was then transferred to the place infested by the rats. Next morning the bladder had again been eaten through at one edge, and upon the mould were numerous and distinct tracings of the rats' tails, evidently caused by the animals sweeping their tails about in the endeavor to find a hole in the paper.

Experiments in Beet-Culture.—In the course of their experiments on beet-culture, Dehérain and Fremy planted some beets in absolutely sterile soils, to which were added from time to time such substances as were thought to be essential for the development of the plant. It was found that the beets continued in the rudimentary state when they received in such soils only distilled water; they increased slightly in weight when common water took the place of distilled; their development was greater still when the water contained soluble phosphates, or salts of potash; but yet the roots never attained the weight of 100 grammes. When for these mineral substances were substituted ammoniacal salts or nitrates, the yield was much better. Normal beets, however, cannot be grown unless to these nitrogenous fertilizers are added phosphates and potash salts. It is worthy of note that, when the beet finds in the soil nitrogen, phosphorus, potash, and lime, it develops as well as in a soil containing humus. To establish this point Messrs. Dehérain and Fremy compared the produce of two such soils, and found that the beets grown in sterile soil were heavier than those grown in rich soil.

On examining the beets grown in plots in the experimental garden of the museum, the authors found them to be very poor in sugar, though the soil was very rich. From this it follows that deficiency of sugar in the beet is not due to exhaustion of the soil. In seeking the true cause, it occurred to Messrs. Dehérain and Fremy to ascertain how much nitrogen the beets contained, and found it to be very large. Hence it appeared that a soil rich in nitrogeneous matters is unfavorable to the production of sugar. This conclusion was confirmed by sundry analyses of beets grown at the museum, at the school of Grignon, and in the departments of Aisne, Nord, and Eure. All the results positively confirm the observations made by the authors, and their conclusion is that, if beets are now less rich in sugar than formerly in those departments which have long produced them, that fact is not owing to the exhaustion of the soil and its deprivation

of principles necessary for the development of the beet; on the contrary, the reason of the phenomenon is, that the soil is too rich in nitrogenous matters, in consequence of the liberal use of manures.

Balloons and Carrier-Pigeons.—It is related by a writer in the London *Quarterly Review* for July, that when Pilâtre de Rozier had descended safely to the earth, after making the first aërial voyage ever undertaken by man, Benjamin Franklin, who at the time (November 21, 1783) was in Paris, on being asked his opinion of the brothers Montgolfier's invention, replied, "A child has just been born." But hitherto its growth has been extremely slow. Nevertheless, the history of aërial navigation is full of interest, and it is well told by the writer in the *Quarterly*. Some of the early objections against ballooning were singular enough. Thus, it was urged that female honor and virtue would be in continual peril, if access could be had by balloons at all hours to the windows of houses! Politicians objected that, if the path of air were to be made free, all limits of property and frontiers of nations would be destroyed. As a matter of course, aërial navigation was denounced as "impious." And, when the brave Pilâtre des Rozier's balloon took fire in the air over the city of Boulogne, and he lost his life, many a one recognized herein the "hand of Providence," just as the peasant-girl, who saw a deal chair fall "from heaven," at once decided that it was a part of the household furniture of the angels. In point of fact, Gay-Lussac, who happened at the time to be overhead, had thrown the chair out of his car, to lighten his aërostat.

During the siege of Paris by the Germans, a balloon post was established in the city. At first there appeared to be innumerable obstacles in the way of this enterprise, the chief one being the difficulty of obtaining a sufficient number of aëronauts. In this strait, the aid of seafaring men resident in the city was invoked, as their training had made them familiar with operations and dangers akin to those of ballooning. From September to January, sixty-four balloons were sent off, and of these fifty-seven fulfilled their mission. The number of letters thus dispatched was 3,000,000. The writer in the *Quarterly Review* mentions one incident connected with these balloon voyages which seems hardly credible: On one occasion, the crew of a balloon found themselves over the sea, out of sight of land. Seeing vessels they made signals for help, but were not answered, *and one vessel fired on them.* The men afterward descended to the earth in Norway.

To carry dispatches and letters *into* Paris, carrier-pigeons were employed. The dispatches, public and private, were first printed on pages of folio size, 16 of which were placed side by side, forming a large sheet about 54 inches long by 32 wide. This was reduced by photography to $\frac{1}{200}$ of its original area, the impression being taken on a small pellicle of collodion, two inches long and $1\frac{1}{4}$ wide, and weighing about $\frac{1}{2}$ of a grain; each contained about 2,000 words, or 32,000 words in all, equal to about 58 pages of this magazine. Every pigeon carried twenty of these leaves, which were carefully rolled up and put in a quill. At the Government office in Paris, the quill was cut open, and the collodion leaves carefully extracted. They were then magnified by an optical apparatus, copied, and sent to their destination.

Mental Overwork.—One of the great evils of modern life, in the estimation of many eminent physicians, is mental overwork. It is asserted that affections of the heart are now more numerous than ever before, that asylums for the insane are being overcrowded, and that nervous disorders of every kind are on the increase. What are the signs which indicate impairment by overwork? This question is thus answered in the *Sanitary Record*: "Overwork," says the *Record*, "exists when the sense of energy once possessed is distinctly impaired; when it is found an effort to get through what was once a cheerful task; when what was once found comparatively easy is beginning to be felt a trial; and above all when errors or omissions, the direct outcomes of a flagging and wearied brain, commence to manifest themselves. To spur on an exhausted brain, and by application and longer hours of toil to compel the overtaxed nervous system to complete its round of duty, is one of the most disastrous and erroneous measures that can

be adopted. Whenever work, itself unaltered, looks larger than of yore, and is felt to be more trying, then the system is commencing to feel the effects of overwork, which, however, may actually have existed for some time unnoticed. This is especially true of the monotonous labor which is undergone by the clerks and subordinate officials of our commercial houses; if they are free from the anxieties which affect the principals, they are the more subject to the wearing action of monotonous labor. The institution of bank holidays is a step in the right direction, and ere long the absolute necessity for a more decided increase in the number of national holidays will be palpable enough. What man can safely do is not to be measured by his desires, but by his powers; and we are all rapidly becoming convinced that incessant toil is not only undesirable, but that it is uneconomical. The one day's rest in seven is not now sufficient for our needs."

French Public Libraries.—In a statistical work, comparing France with other European countries, the following interesting notes on public libraries occur: Paris has six great libraries, the property of the state, and open to the public, viz.: Bibliothèque Nationale (900,000 volumes), Bibliothèque Mazarine, Bibliothèque de l'Arsenal, Bibliothèque Sainte-Geneviève, Bibliothèque de la Sorbonne. Outside of Paris France has 338 libraries which twenty years ago contained 3,689,000 printed volumes. Forty-one of these libraries are open in the evening. Great Britain has (in its public libraries) 1,771,493 volumes, or six volumes per 100 of the population; Italy 11.7 volumes per 100. In France there are 4,389,000 volumes, or 11.7 per 100 persons; in Austria 2,488,000 volumes, or 6.9 per 100; Prussia 2,040,450, or 11 per 100; Russia 852,000, or 1.3 per 100; Belgium 509,100, or 10.4 per 100. Since 1865 school libraries have been founded nearly throughout all France. We have already in the MONTHLY given the statistics of these school libraries, but we copy the figures again from the work to which we are indebted for the foregoing statistics. In 1865 there were 4,833 of these school libraries in France, containing 180,854 volumes; in 1866, 7,789 libraries, 258,724 volumes; 1867, 11,417 libraries, 721,853 volumes; 1868, 12,395 libraries, 988,728 volumes; 1869, 14,395 libraries, 1,239,165 volumes; 1870–'71, 13,638 libraries, 1,158,742 volumes.

Appearances attending the Passage of a Meteor.—In stating the results of his observations on the passage of a meteorite seen at Louisville, December 12, 1872, Prof. J. Lawrence Smith says that it first appeared as a large red light in the zenith, which seemed to stand motionless for several seconds, evidently because it was then descending in a line with the eye of the observer. Then starting off with an uncertain, faltering motion, it moved slowly toward the horizon, gradually fading from a lurid red to a dark purplish hue, and leaving a dense stream of blue smoke behind, which remained for several minutes. "These clouds," continues Prof. Smith, "are not unfrequently connected with the passage of these bodies through our atmosphere, and are usually more striking in the daytime, or, as in this instance, just after sunset, when the sun was well situated to light up the cloud and exhibit it to the observer who could no longer see the sun. What are these clouds? Are they composed of impalpable matter abraded from the surface of these bodies in their passage, or are they true vapor-clouds? From a close study of observations in connection with several well-known falls of meteorites, I am more inclined to adopt the former view; but there is reason for believing that the violent disturbance of a portion of the atmosphere (much of it, in the rapid passage of the body, undergoing great condensation), added to an undoubted electric disturbance of the atmosphere, would tend to the deposition of moisture, upon the atmosphere being gradually restored to its former equilibrium."

Insect-killing Plants.—During a botanical tour in Atlantic County, New Jersey, Mr. Meehan, of Philadelphia, found growing, near Hammonton, a great number of plants representing three species of *Drosera*, namely, *D. filiformis*, *D. longifolia*, and *D. rotundifolia*. All of these species had insects attached to them, but many of the plants had none. The remains of the insects which have been caught seem to

continue attached to the plant for a long time, and thus the observer at once perceives which plant has had the benefit of animal food. No difference in health or vigor could be detected between those which had had insects and those which had not. This, however, does not by any means decide the question whether the plants do or do not digest the insects. As Mr. Meehan remarks, the case of these plants is comparable to that of vegetarians and flesh-eaters among mankind; it is a question which class is the healthier. A plant, he said, might feed on insects, and yet be no healthier than those which lived as other plants did. But the author does not see how this faculty of catching and digesting insects could be developed by natural selection. "It is believed," said he, "that the power to catch insects is a developed one—a power not possessed by their predecessors—and developed according to the law of natural selection. Unless insect-catching can be shown to be an especial advantage, there is nothing to select." Among the many *Droseras* observed by Mr. Meehan on this occasion, only one presented the phenomenon of the leaf bending over on itself, and so enfolding the prey.

The Soda-Lakes of Wyoming.—An account of the soda-lakes of Wyoming Territory is given in the report of Mr. Pontez, geologist of the Union Pacific Railroad. He describes two such lakes, the larger one covering about 200 acres. The average depth of water in this lake is three feet, and its specific gravity 1.097. The soda is nearly all carbonate. The second lake is situated near the first, and covers about 3½ acres. During the greater part of the year it is a concrete mass of carbonate-of-soda crystals. Mr. Pontez excavated to the depth of six feet without reaching the bottom of the deposit, which is constantly increasing from the influx from the larger lake. These lakes are situated about 65 miles from Rawlins Station, on the Union Pacific Railroad. The quality of the carbonate is declared to be fully equal to the imported article. Estimating the quantity by the specific gravity of the water, its depth and area, the large lake would yield on evaporation 78,000 tons, which would realize, at $45 per ton, $4,510,000. Besides the cost of freight, the expense of preparing the article for market would be $4 per ton for evaporating. The small lake already crystallized, and estimated only at a depth of six feet and an area of 155,000 feet, contains 30,660 tons, which at $45 per ton would realize $1,379,700.

Refraction of Sound.—Refraction of sound by the atmosphere was the subject of a paper read by Prof. Osborne Reynolds, at the last meeting of the British Association, in which were given the results of experiments made by the author. He had confirmed his hypothesis that when sound proceeds in a direction contrary to that of the wind it is not destroyed or stopped by the wind, but that it is lifted; and that at sufficiently high elevations it could be heard at as great distances as in other directions, or as when there is no wind. An upward diminution of temperature had been proved by Glaisher's balloon-ascents, and he showed, by experiments with the sounds of firing of rockets and guns, that the upward variation of temperature had a great effect on the distance at which sounds could be heard. By other observations, he found that when the sky was cloudy and there was no dew, the sound could invariably be heard much farther with than against the wind, but that, when the sky was clear and there was a heavy dew, the sound could be heard as far against a light wind as with it.

The Opium-Habit.—The British vice-consul at Kinkiang, China, in a report to his government, states certain facts coming under his own observation, which seem to show that the opium-habit may exist without detriment to health. During a tour on the Upper Yang-tse-kiang, he was thrown into the closest relations with junk-sailors and others, almost every adult of whom smoked opium. Their work was of the hardest, rising at 4 A. M., and working, with hardly any intermission, till dark, having constantly to strip and plunge into the stream in all seasons. The quantity of food eaten by them was prodigious, and from this and their work it may be inferred that their constitution was robust. The two most addicted to the habit were the pilot and the cook. On the incessant watchfulness and steady nerve of the former the safety of the

junk and all on board frequently depended; the other worked hard from 3 A. M. to 10 P. M., and often longer. This cook had a conserve of opium and sugar, which he chewed during the day, as he was able to smoke only at night.

NOTES.

By a mistake of the printer, the heading to Dr. Jerome Kidder's advertisement in the last number of the MONTHLY was made to read, "Superior Electro-*Chemical* Apparatus." It should have read, "Superior Electro-Medical Apparatus," as it now stands.

Last summer the French Assembly voted to M. Pasteur a life-pension of 12,000 francs, in consideration of his public services as a scientific investigator. Another pension of 6,000 francs was lately allowed him by a decree of the Marshal-President.

In conjunction with the U. S. Fisheries Commission the Smithsonian Institution will exhibit at Philadelphia the resources of the United States derivable from the waters, including the objects themselves, the products derived from them, the apparatus by which the objects are captured or utilized, and finally the means by which they are multiplied and maintained in a healthy state. The last section is intended to illustrate the present state of pisciculture in this country.

At the annual meeting of the American Microscopical Society of the City of New York, held on January 25th, Dr. John B. Rich was elected President, and Mr. C. F. Cox, 13 William Street, Secretary for the present year.

The Loan Collection of Scientific Instruments, soon to be placed on exhibition in London, will undoubtedly be the most successful enterprise of the kind ever attempted. Nearly every civilized country will be represented. Not only modern instruments, but also those possessing a more strictly historical interest—such as apparatus once used by Galileo, Tycho Brahe, Lavoisier, Priestley, Boyle, Herschel, etc.—will have a place in this collection.

In some parts of Russia the young shoots of the "cat-tail" (*Typha latifolia*) are used as asparagus; they are said to be delicious. The plant grows abundantly in the United States in swampy localities.

Captain Allen Young will sail again next May, from England, to renew the search after the remains of Sir John Franklin's expedition. He will first visit the entrance of Smith Sound, with a view to receive intelligence from the Alert and Discovery.

The death is announced of George Poulett Scrope, the geologist. He was born in 1797, and received his education at Harrow School and Cambridge University. In 1825 he published his first scientific work, "Considerations of Volcanoes." Two years later he published a treatise on "The Geology and Extinct Volcanoes of Central France," a work of signal merit. In 1833 he entered political life as a member of Parliament, and published a number of pamphlets on a variety of governmental topics. His later scientific writings consist of articles contributed to the *Journal of the Geological Society* and the *Geological Magazine*.

A signal for the use of the Coast Survey has been erected on the summit of Mount Shasta, California, at an elevation of 14,402 feet. It is described in the *Scientific American* as being a hollow cylinder of galvanized iron 12 feet high and 2½ feet in diameter, surrounded by a cone of nickel-plated copper, with concave sides, 3 feet high and 3 feet in diameter at the base. The nickel-plated cone is a brilliant reflector and will reflect the sunlight in such a manner that the reflection can be seen for a distance of 100 miles or over.

One of the grandest engineering projects of the time is the union of the Black and Caspian Seas. The plan is to join by a canal the tributaries of the Manytch and the Kouma, two considerable rivers which drain the northern slope of the Caucasus. If these two seas were united, the naval force of Russia would be practically doubled, for then her Caspian fleet could, in case of necessity, be added to that which holds the Black Sea.

An old lioness in the Dublin Zoölogical Gardens was, during her last illness, much worried by rats, against which she could no longer defend herself. A terrier dog having been placed in the cage to protect the sufferer, the lioness at first received him with a surly growl; but, when she saw him kill the first rat, she began to appreciate her visitor. The lioness coaxed the terrier to her, folded her paws round him, and the dog slept each night on her breast enfolded with her paws, and protecting her rest from disturbance.

It is stated in the *Tribune* that Prof. S. S. Haldeman recently found in an excavation in the vicinity of Chickies, Pa., a large number of Indian relics. The collection includes one hundred pieces of pottery, sixty stone arrow-heads, and one of copper; a tomahawk, eight stone chisels, several mallets and pipe-stems; also a few of those instruments commonly called "sinkers," but the proper use of which is unknown.

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